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PROJECT MANAGER, M60 TANKS

TECHNICAL REPORT

NO. 12769

FINAL TEST REPORT
M60 TANK PERSONNEL HEATER
Comparison Test

FORT CARSON, COLORADO
Dec 82 - Mar 83

Final Report

CONTRACT NO. N/A

MAY 1983

by Major Glenn F. Rogers & William L. Ashley III
(DRCPM-M60-E)
Charles B. Fleetham (DRSTA-MCB)
U.S. Army Tank-Automotive Command
Warren, Michigan 48090

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This heater comparison test was initiated in an effort to improve heater system reliability by evaluating design changes to both the heater and the heater support system in an operational environment. The results of this test presented in this report will be used by DOD officials in their decision making process regarding the acceptance or rejection of the proposed design changes.

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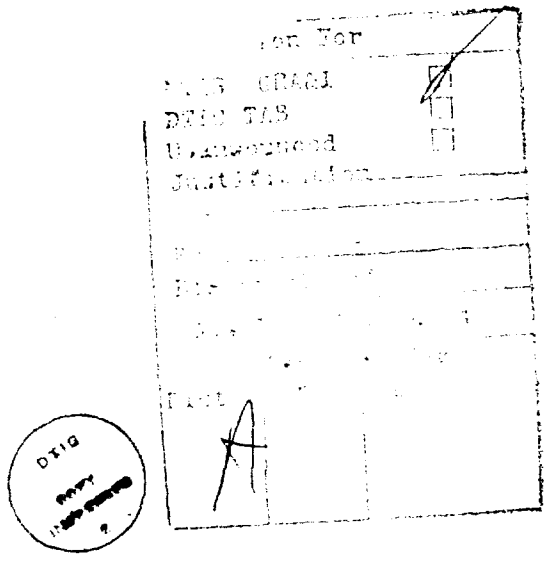
PREFACE

The authors wish to acknowledge the significant contributions of the officers and men of 4th Battalion, 40th Armor, 4th Infantry Division, Ft. Carson, Colorado. The unit volunteered to conduct this heater test and to abide by the data collection requirements without relief from their already demanding training schedule. SGT Paulson of the Ft. Carson Direct Support Fuel and Electronics Repair Shop consistently provided speedy and competent repair of failed heaters and did an excellent job of reporting his activities via written data collection reports. The 4th Infantry Division Headquarters and Staff (particularly CW4 Maddox of the DMMC) provided the necessary approval to conduct the test and cooperated fully with the numerous requests for assistance throughout the test. Without the assistance of these dedicated soldiers, this test report would not have been possible.



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1.0. INTRODUCTION

1.1. Heater Reliability

The tank personnel heater subsystem was declared a vehicle shortcoming by the Test and Evaluation Command (TECOM) in their M60A3 Tank Development Test III (DT III) final report. The Model "B" personnel heater was determined to be neither durable nor reliable because of numerous failures to operate as well as accidental discharge of the vehicle fire extinguishers. Although the Model "B" was replaced by the Model "C" in May 1980, the problems still persist.

The M60 Sample Data Collection (SDC) program consistently indicates that the Model "C" heater is the component on the tank which fails most often on new M60A3 tanks stationed in West Germany. Cost figures provided by the National Inventory Control Point (NICP) at TACOM indicate frequent heater replacements and high demands for repair parts are occurring in the field.

In October 1980, PM-M60 sponsored a 5 month heater comparison test at Fort Knox, Kentucky involving four types of heaters distributed over a total of 15 test tanks. Conclusions drawn from the test data indicate the reliability of the Model "C" heater was indeed poor and none of the three alternative heaters tested were significantly more reliable.

1.2. Heater Working Group

Recognizing this to be a long standing problem across all TACOM managed vehicle lines, BG Stallings, Deputy Commanding General for Readiness, chartered an in-house Heater Working Group (HWG) on 7 June 1982. One of several significant HWG initiatives has been the complete revision of the heater specification. The revised specification will be applicable to all 60,000 BTU diesel fuel burning personnel heaters mounted in vehicles managed by TACOM.

The new specification has been staffed through each Program/Project Manager (PM). Extracts of the new specification are attached at Appendix E.

Significant differences in performance requirements between the old and new heater specifications are shown below:

- Reliability requirement for a minimum acceptable mean-time-between-failure (MTBF) of 600 hours was added.
- 800 hour Endurance Test requirements were changed to add a requirement to burn three different diesel fuels and to drastically reduce the type and frequency of maintenance allowed during the test.
- Requirement for automatic fuel purging after an overheat condition has been added.
- Detailed requirements for the flame detector control have been added.
- Requirement has been added to provide for various mounting positions in different vehicles (M88 is vertical, M60 is horizontal).

- Maximum allowable fuel consumption has been increased from 0.085 pounds per minute (lbs/min) on high heat to 0.092 lbs/min and from 0.047 lbs/min on low heat to 0.052 lbs/min.
- Additional air discharge rate requirements have been added for various back pressures.
- Requirement for limiting the ventilating air outlet temperature has been added.
- Shock and vibration requirments were defined in more detail.

1.3. Model "A" Heater

Stewart-Warner Corporation, South Wind Division, developed a new SW 10660A prototype heater in hopes of satisfying the revised specification. The exterior physical differences are shown in figure 1-1.

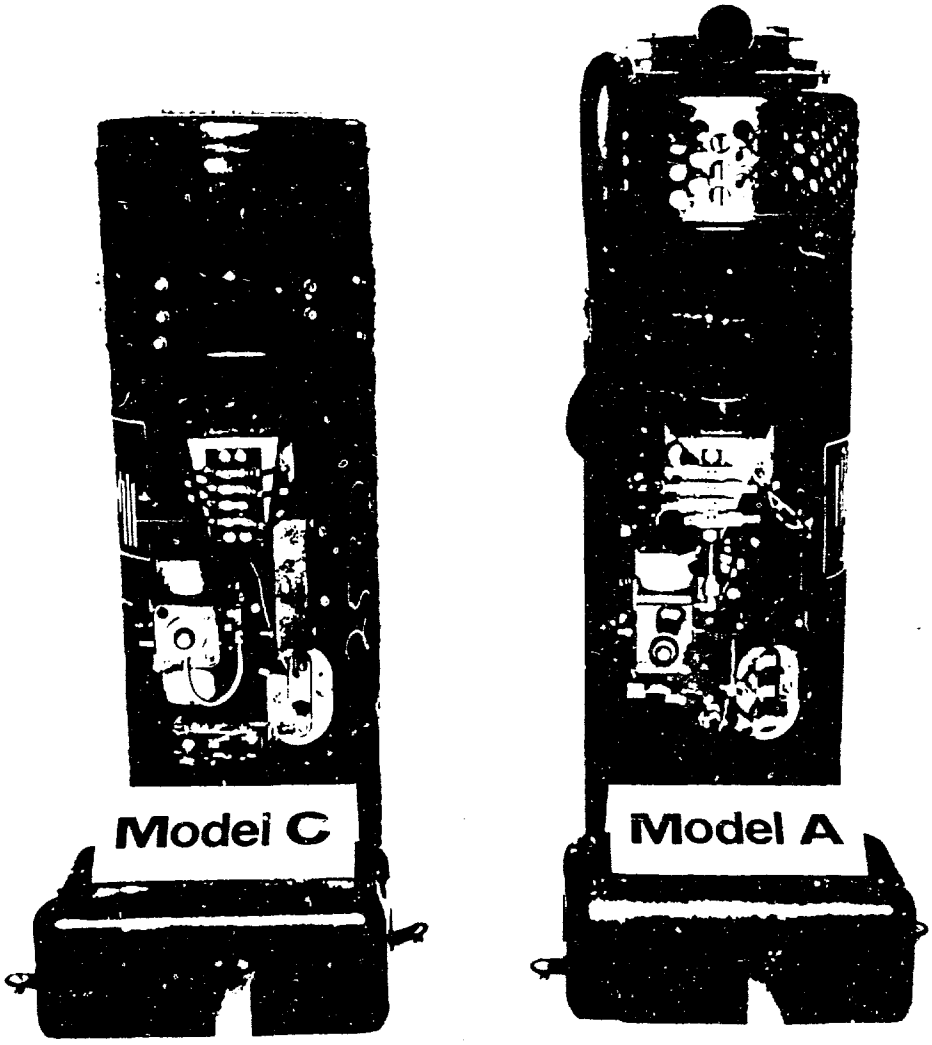


Figure 1-1.

A comparison of the two heaters by internal components is shown below:

Heater Comparison

Component	Model "C"	Model "A"
Igniter	Resistor	Same as "C"
Burner	Wick Vaporizer	Same as "C"
Flame Detect Switch	Heat-Operated Microswitch	Thermocouple with Electronic Timing Control
Overheat Switch	Cycles Off at Overheat	Cycles Between Hi-Lo and Cuts out at Overheat
Igniter Control	Resistor in Series with Igniter	Electronic Voltage Regulator
Fuel Control	Hi and Lo Heat Orifices Controlled by Two Solenoids	Hi or Lo Pulsating, Flow Through Single Large Orifice Electronically Controlled
Motor	Single Fan	Dual Fan
Combustion Air	Single Source	Dual Source

Figure 1-2. is a cutaway view of the Model "C" heater with the various parts labeled. Figure 1-3. is a similar view of the Model "A" heater. A functional schematic for each heater is illustrated in figures 1-4. and 1-5.

STEWART WARNER MODEL "C" HEATER

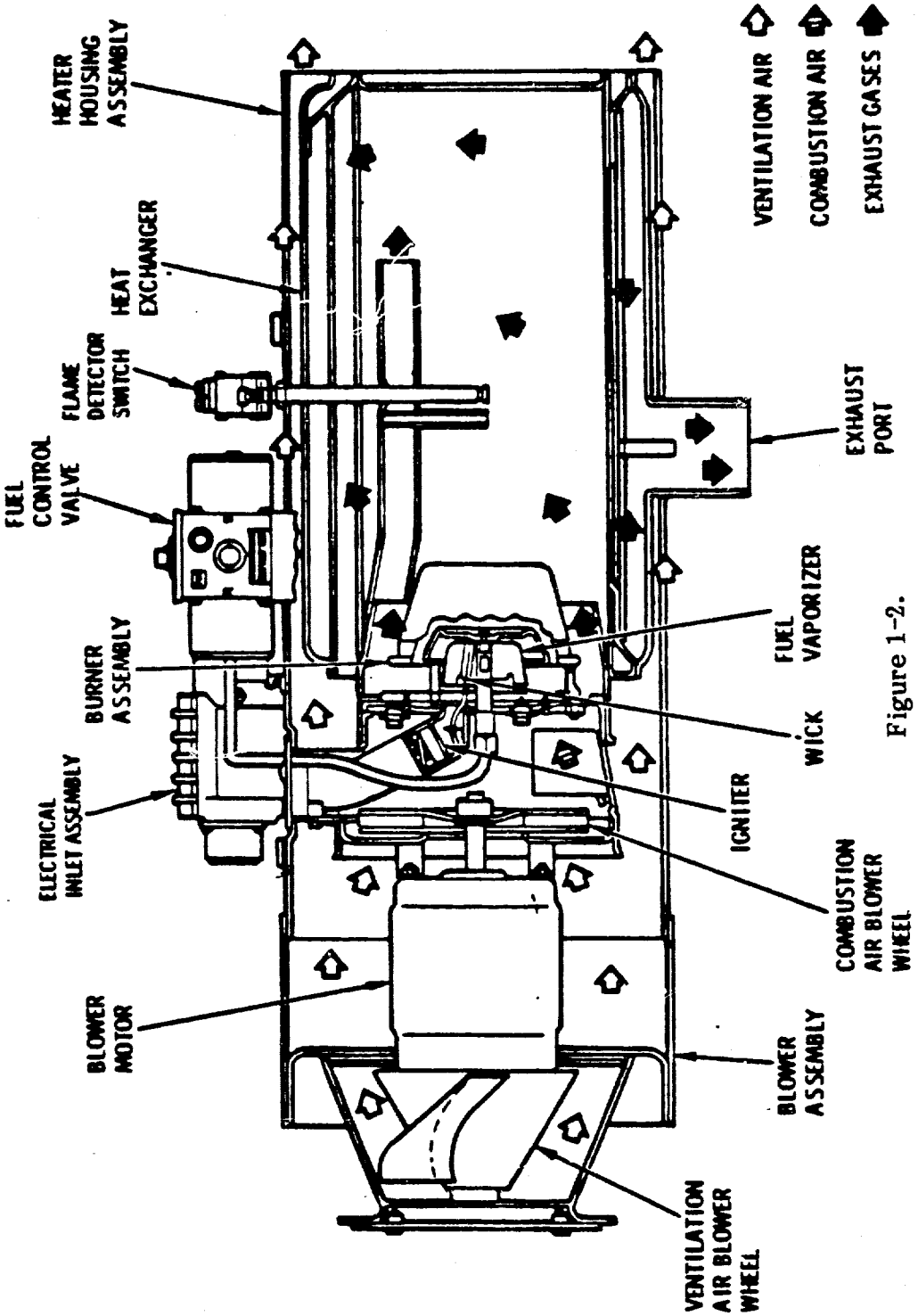
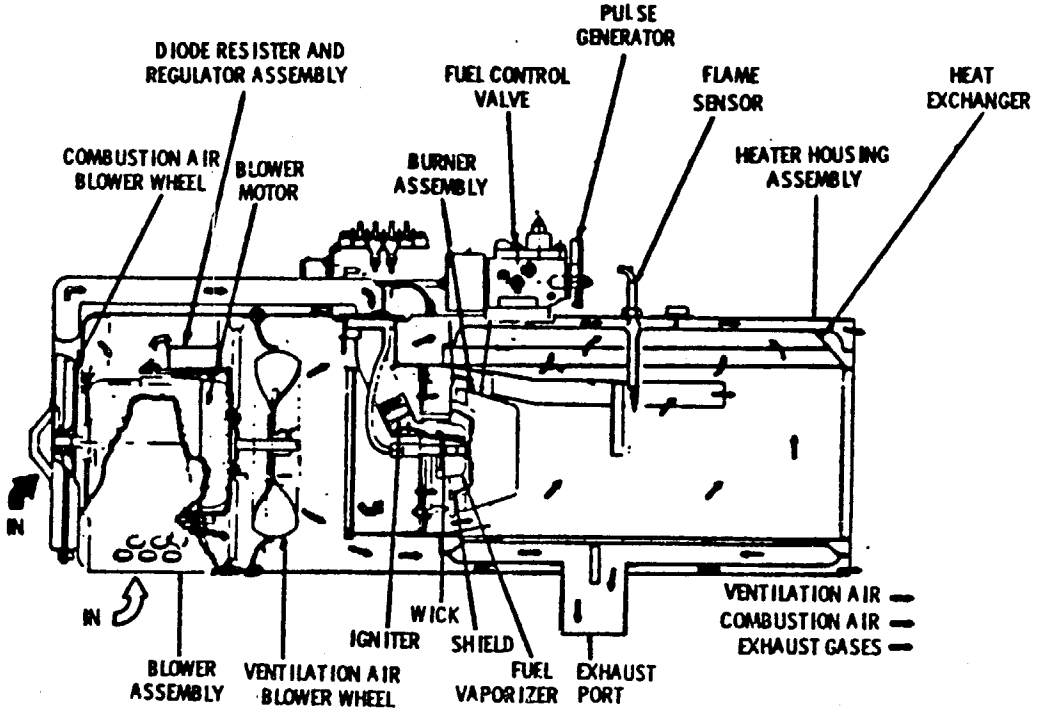
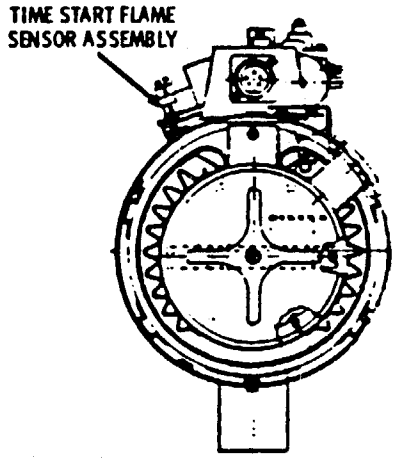


Figure 1-2.

STEWART WARNER MODEL "A" HEATER





AIR FLOW DIAGRAM &
CROSS SECTIONAL VIEW

Figure 1-3.

MODEL "C" HEATER
FUNCTIONAL SCHEMATIC

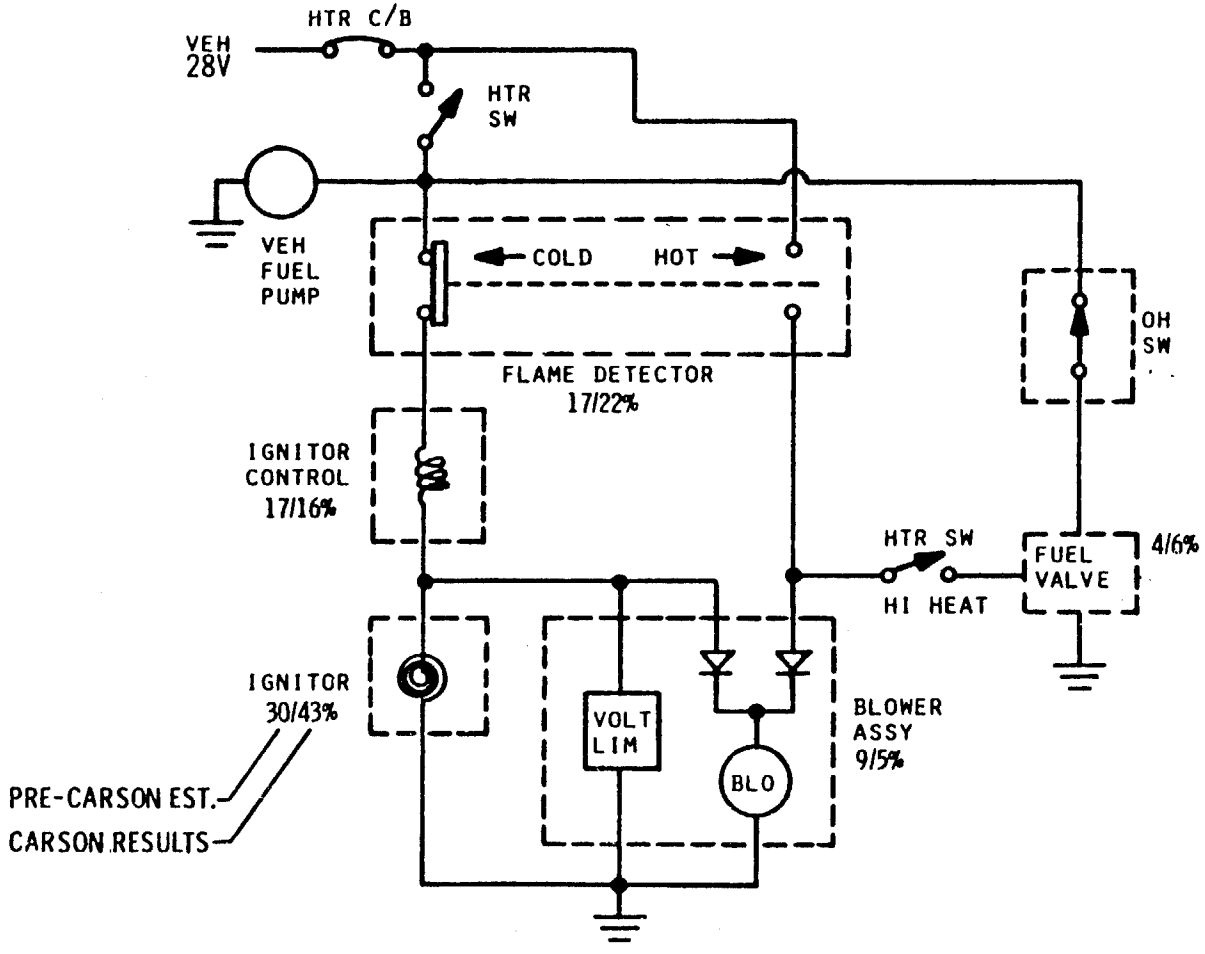


Figure 1-4.

MODEL "A" HEATER
FUNCTIONAL SCHEMATIC

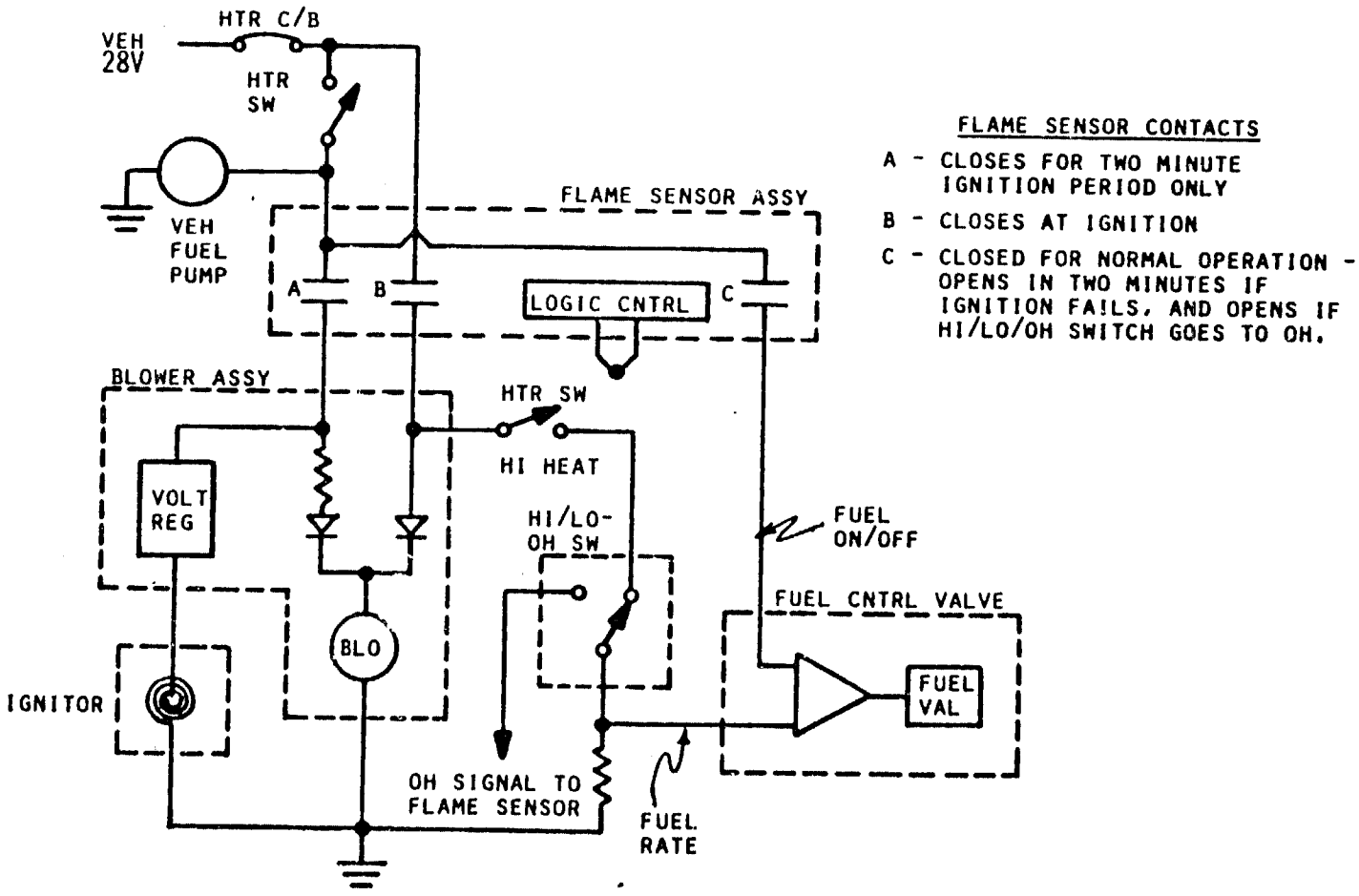


Figure 1-5.

1.4. Test Concept

PM-M60 Engineering Division elected to design a user test in an operational environment to evaluate both the proposed Model "A" heater as well as several changes to the heater support system suggested by the Systems Integration Contractor, General Dynamics Land System Division (GDLS). The revised specification was developed as an open - source procurement document suitable for competitive solicitation. It was fully intended by PM-M60 Engineering that samples from at least two contractors would be utilized in this test program; however, only Stewart-Warner developed and delivered hardware within the time constraints imposed. The results of this field test are believed representative of any potential supplier's item which has first demonstrated conformance to the proposed specification MIL-H-62315A (AT). Ft. Carson was selected as the test site in order to obtain a large sample size of test vehicles and to measure the reliability of the heater system in an operational environment. This would include the effects of soldier operation and maintenance. The test was funded totally by the PM-M60 Office using PAA (Procurement) funds.

2.0 TEST OBJECTIVES

- To determine whether the SW 10660A heater provides substantial reliability improvement over the SW 10560C heater.
- To determine whether the proposed engine filter (heat tape) heater support system contributes substantially to heater system reliability with either heater.
- To determine whether the proposed "DAVCO" heater support system contributes substantially to heater system reliability.

3.0 CONCLUSIONS

- The SW 10660A heater demonstrated a dramatic improvement in reliability over the SW 10560C heater during the Ft. Carson Test. Considering chargeable heater failures only, the Model "A" heater demonstrated a 97 percent confidence that it can achieve at least 600 hours between failures (the minimum acceptable MTBF under the revised specification). In contrast, the Model "C" heater only demonstrated 70 or more hours at 90 percent confidence. The Mean Hours Between Failures (MHBF) of the Model "A" heater was greater than 2140 hours, while the MHBF for the Model "C" heater was 152 hours.

- Crews have confidence that the Model "A" heater will start. The Mean Starts Between Failures (MSBF) for the Model "A" heater was greater than 779, while the MSBF for the Model "C" was only 25. Crew confidence was manifest in the mode of operation used and from interviews and questionnaires.

- No significant difference was noted in the performance of any of the heater support systems on test, possibly due to lack of severe cold weather.

- The SW 10560C heater is sensitive to fuel supply problems, unauthorized tampering with controls, and electrical problems. The SW 10660A heater did not exhibit these characteristics during the Ft. Carson Test.

- The "DAVCO" heater support system caused difficulty in installing or removing the tank powerpack because of excessively close fit tolerances.

- The location and configuration of the heater hot air duct may contribute to discharge of the portable fire extinguisher on M60A1 tanks. The "Improved" hot air duct may exacerbate this condition.

- The effect of the "Improved" hot air duct on heater performance was insignificant.

- The electrial changes to the Driver's Instrument Panel (DIP) on both the "Engine Filter" and "DAVCO" support systems preclude the operator from turning the heater power off before the heater completes the purge cycle. The Model "A" heater internal electric circuit precludes the operator from causing heater ignition circuit failures (shorted igniters and ignition controls) by repeated unsuccessful start attempts.

4.0. RECOMMENDATIONS

- Consideration should be given to release the Model "A" heater as soon as it has met all regulatory requirements.
- The "Engine Filter/Heat Tape" support system should be tested under controlled conditions which will test its ability to deal with paraffin clouding and icing.
- A study should be made considering the logisitcs and cost implications of developing a kit to upgrade the Model "C" heater to include self-protection and other design features of the Model "A" heater.
- The design of the hot air duct should be reexamined in order to provide the driver more comfort and prevent unnecessary discharge of fire extinguishers.
- Any heater or support system changes made should include the changes to the Driver's Instrument Panel (DIP).
- The Model "A" heater with "Engine Filter/Heat Tape" support system should be tested at the Cold Regions Test Center (Alaska) during the winter of 1983-84 to evaluate the hardware in extreme cold.
- The Model "A" heaters used in this test at Ft. Carson should be installed in vehicles belonging to the Test and Evaluation Command (TECOM) for use during the winter of 1983-84 to confirm the reliability of the Model "A" heater with the standard M60 Tank heater support system.

5.0. DISCUSSION

5.1. Test Vehicle Configuration

5.1.1. Test Heater Support System Descriptions. For the purposes of this test, the heater support system is defined as all vehicle components necessary to provide fuel from the vehicle fuel tanks and electrial power to the heater. The PM-M60 Office has configuration management responsibility for all the vehicle components within the support system while Tank-Automotive Command has similar responsibility for the heater itself. The three distinctly different systems described below were selected for testing: (see figure 5-1. for a comparison of systems by components).

- Standard Production: (See figure 5-2.)
  - 1/4" I.D. metal fuel lines from engine compartment to heater in driver's compartment.
  - In-line 3 oz capacity fuel filter with 10 micron filter element located in driver's compartment (M60A1 RISE Passive and later models only).
  - Heater fuel pump with 40 micron filter element located in driver's compartment.
- Engine Filter/Heat Tape: (See figure 5-3.)
  - 1/2" I.D. fuel lines (combination of metal and flexible hose segments) from engine compartment to heater in driver's compartment.
  - New, larger capacity (32 oz) in-line fuel filter with 40 micron filter element and manual drain cock located in driver's compartment.
  - Carry-over (standard) heater fuel pump mounted in the driver's compartment.
  - 44" section of flexible fuel hose in driver's compartment equipped with an integral 18" long heating element to warm the fuel.
  - Electrical wiring changes to the driver's instrument panel (DIP) to accommodate the heating element.
  - Replace DIP heater master switch with circuit breaker. Replace heater operating decal instructions. (Prevents driver from inadvertently turning off heater master power prior to heater completing the fuel purge cycle.) See figure 5-4. (Old Instructions) and figure 5-5. (New Instructions.)
- "DAVCO" Heated Fuel Water Separator: (See figure 5-6.)
  - 1/2" I.D. fuel lines (combination of metal and flexible hose segments) from engine compartment to heater in driver's compartment.
  - New electric in-line heated fuel-water separator (manufactured by DAVCO) with 3 micron filter element mounted on the bulkhead inside the engine compartment.

COMPARISON OF HEATER SUPPORT SYSTEMS

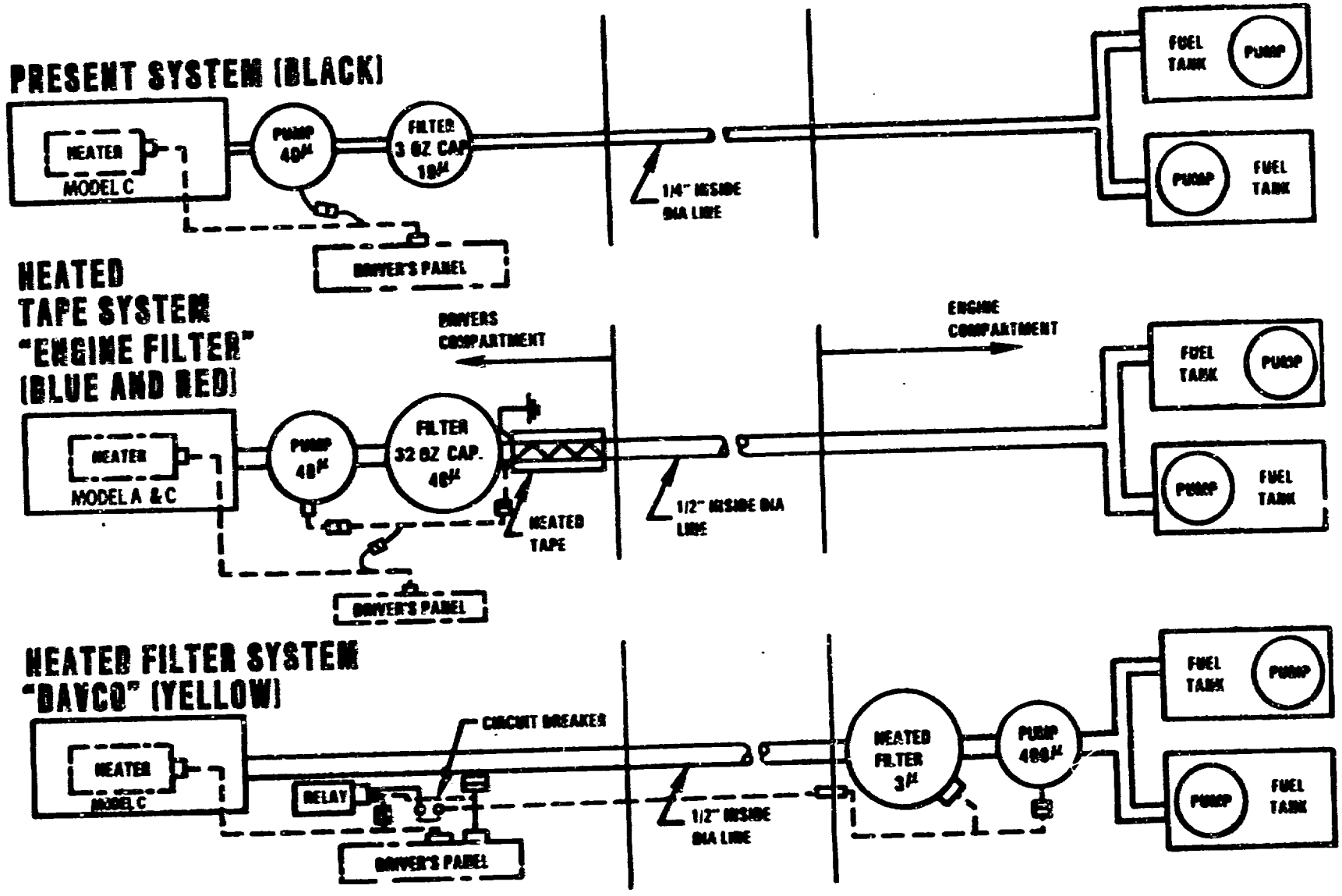


Figure 5-1.

STANDARD PRODUCTION SUPPORT SYSTEM
BLACK

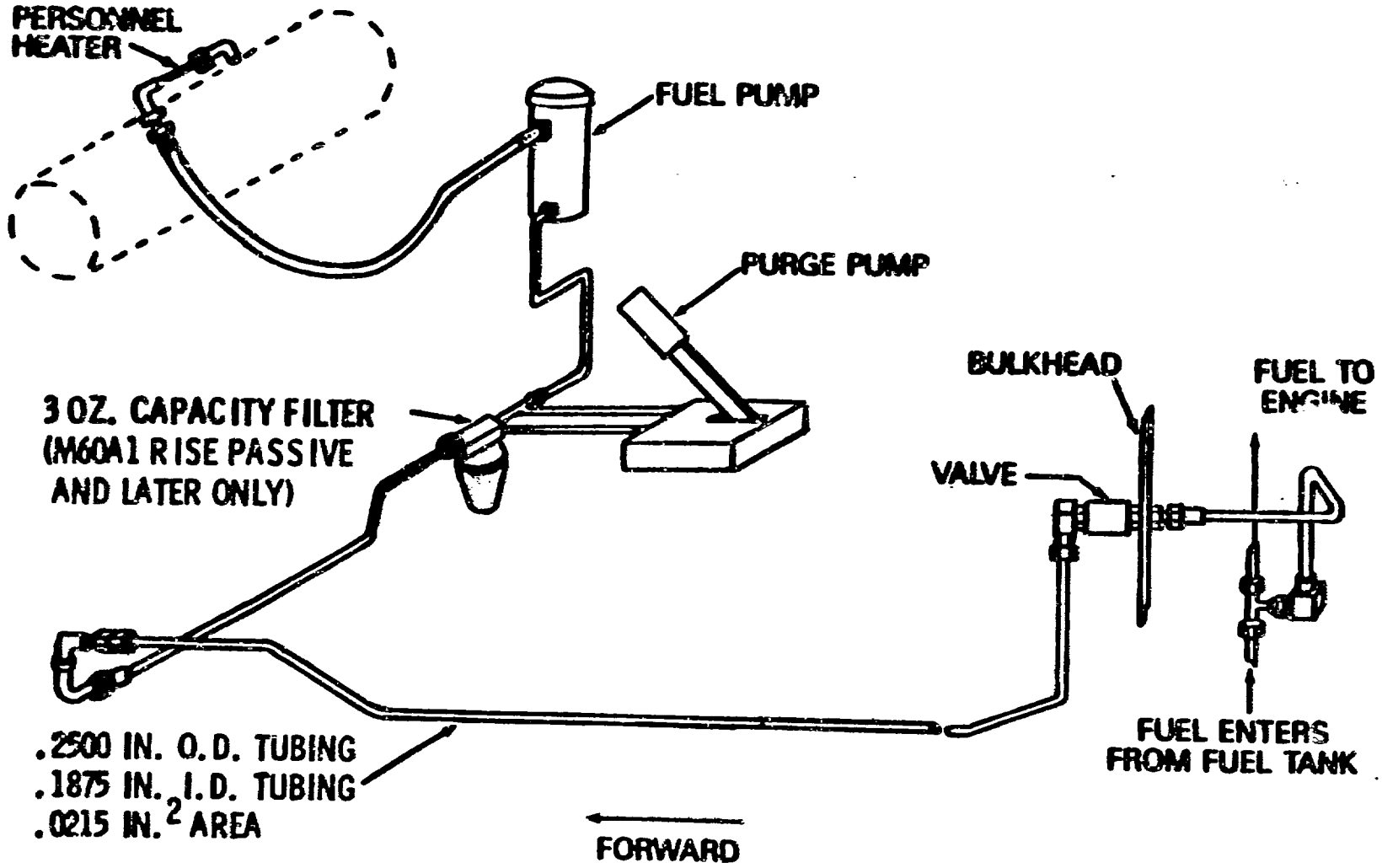


Figure 5-2.

ENGINE FILTER (HEAT TAPE) SUPPORT SYSTEM BLUE AND RED

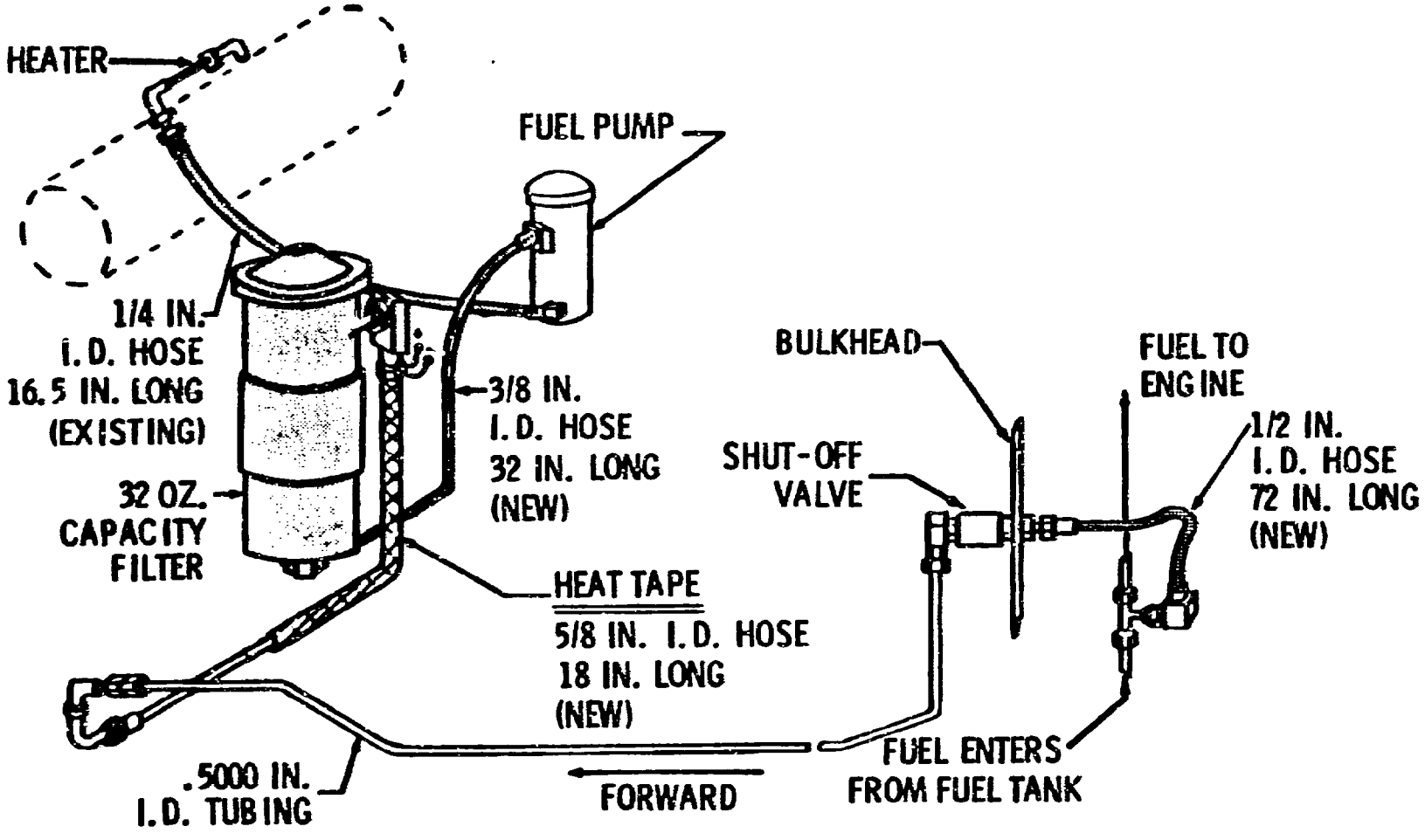


Figure 5-3.

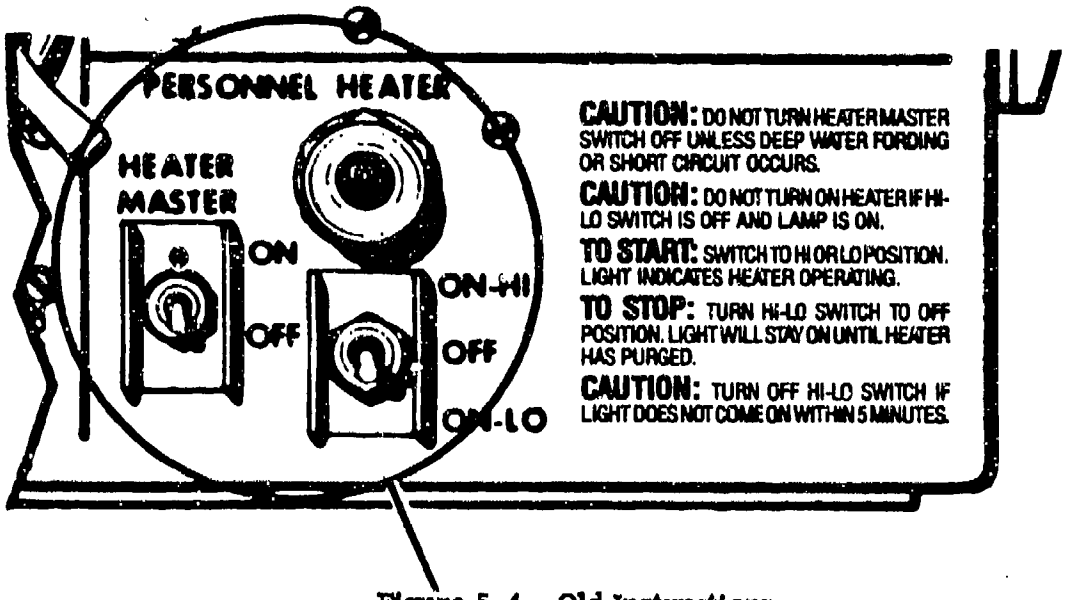


Figure 5-4. Old Instructions

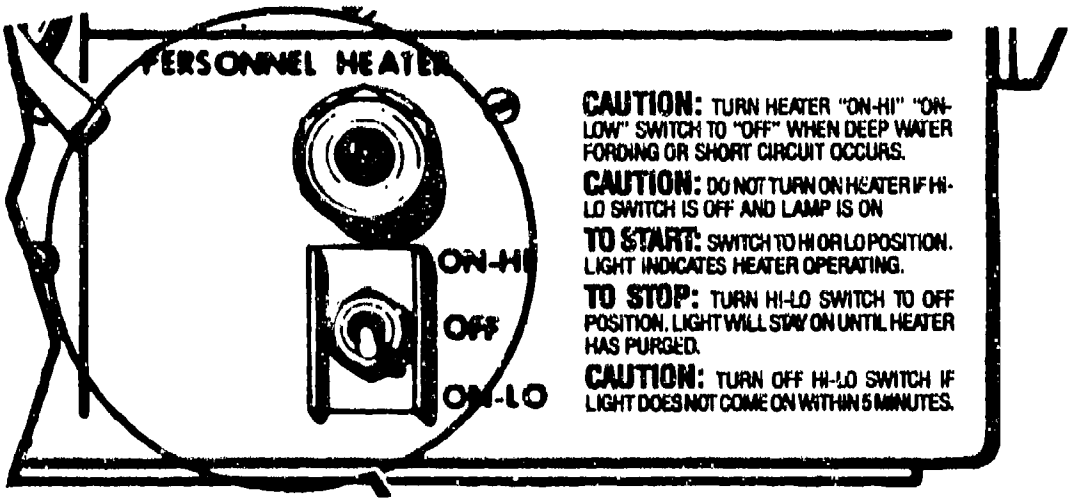


Figure 5-5. New Instructions

"DAVCO" HEATED FUEL WATER SEPARATOR SUPPORT SYSTEM YELLOW

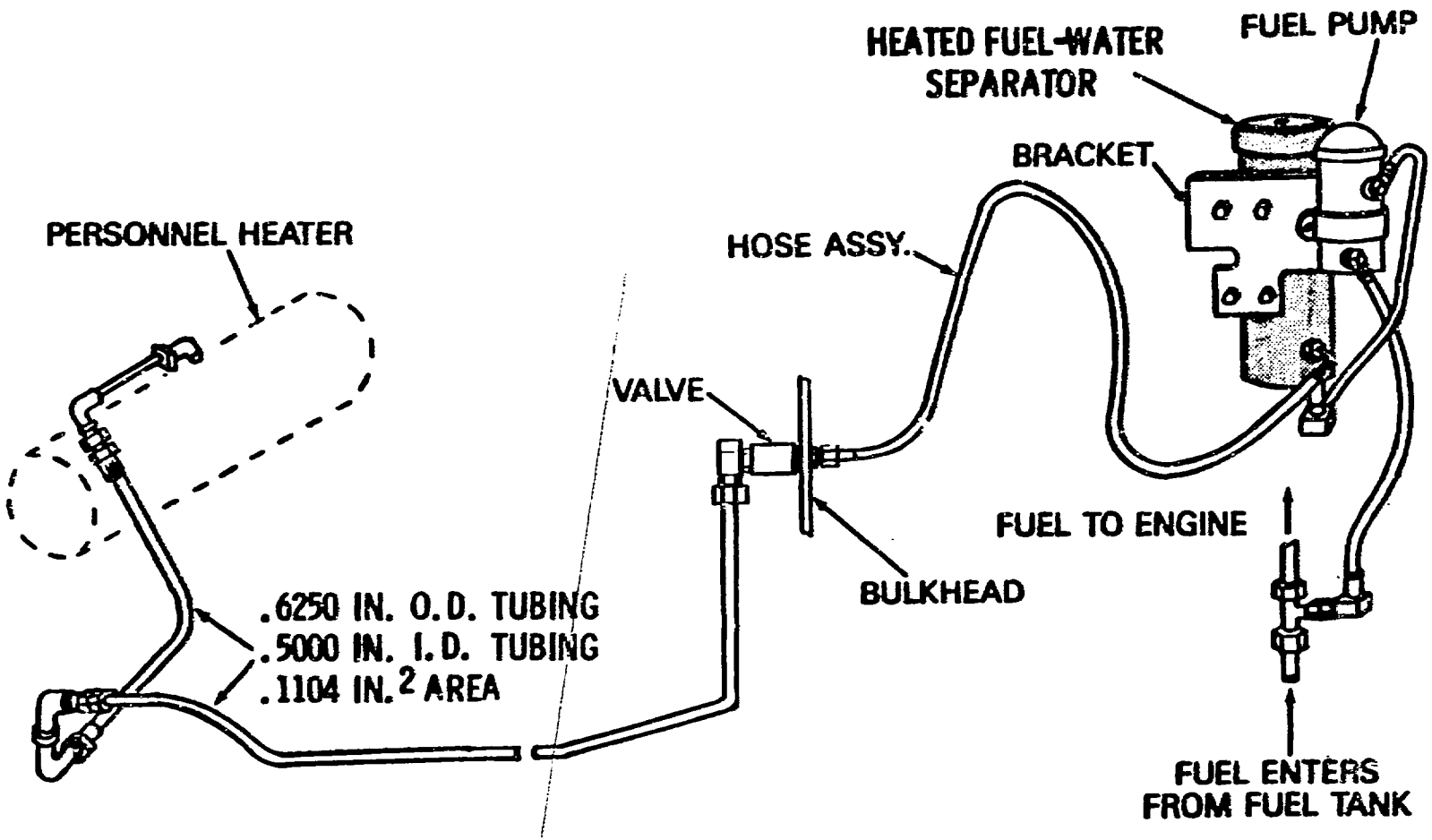


Figure 5-6.

- Carry-over (standard) heater fuel pump with new 400 micron filter element colocated with the DAVCO unit in the engine compartment.
- Electrical wiring changes to the DIP and addition of a new harness, circuit breaker and relay to accommodate the DAVCO unit and fuel pump.
- Replace DIP heater master switch with circuit breaker and replace instruction decal (same as heat tape system above).

5.1.2. Hot Air Distribution Systems. Like the heater support system, PM-M60 has configuration management responsibility for the components of the hot air distribution system. The two types of systems tested are described below:

- Standard Production: (See figure 5-7.)
  - 4" Continous flexible ducting to turret crew compartment.
  - Fixed (non-adjustable) driver's deflector.
- Improved Design: (See figure 5-8.)
  - 5" flexible ducting to turret crew compartment except for a 26" section of 4" duct remaining behind the ammunition rack. Duct extends 12" further into the turret area.
  - New, adjustable driver's deflector.

5.1.3. Hardware Groupings by Color Code. The various production and prototype components selected for test were grouped and assigned color coding for identification and tracking as described below:

- Blue System — Model "A" Heater
Engine Filter/Heat Tape Support System
Improved Design Hot Air Distribution System
- Red System — Model "C" Heater
Engine Filter/Heat Tape Support System
Improved Design Hot Air Distribution System
- Yellow System — Model "C" Heater
"DAVCO" Heated Fuel-Water Separator Support System
Improved Design Hot Air Distribution System
- Black System — Model "C" Heater
Standard Production Support System
Standard Production Hot Air Distribution System

IMPROVED DESIGN AIR DISTRIBUTION SYSTEM

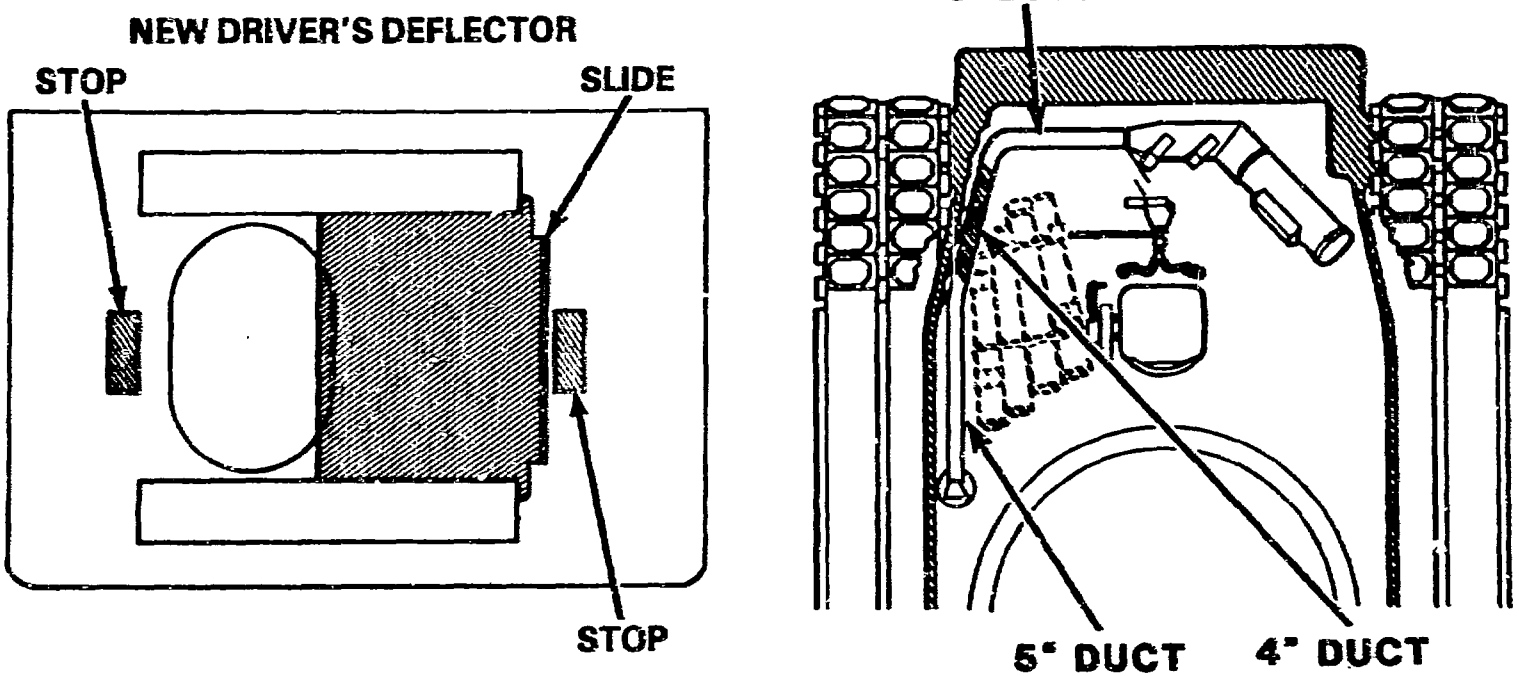


Figure 5-7.

STANDARD PRODUCTION AIR DISTRIBUTION SYSTEM

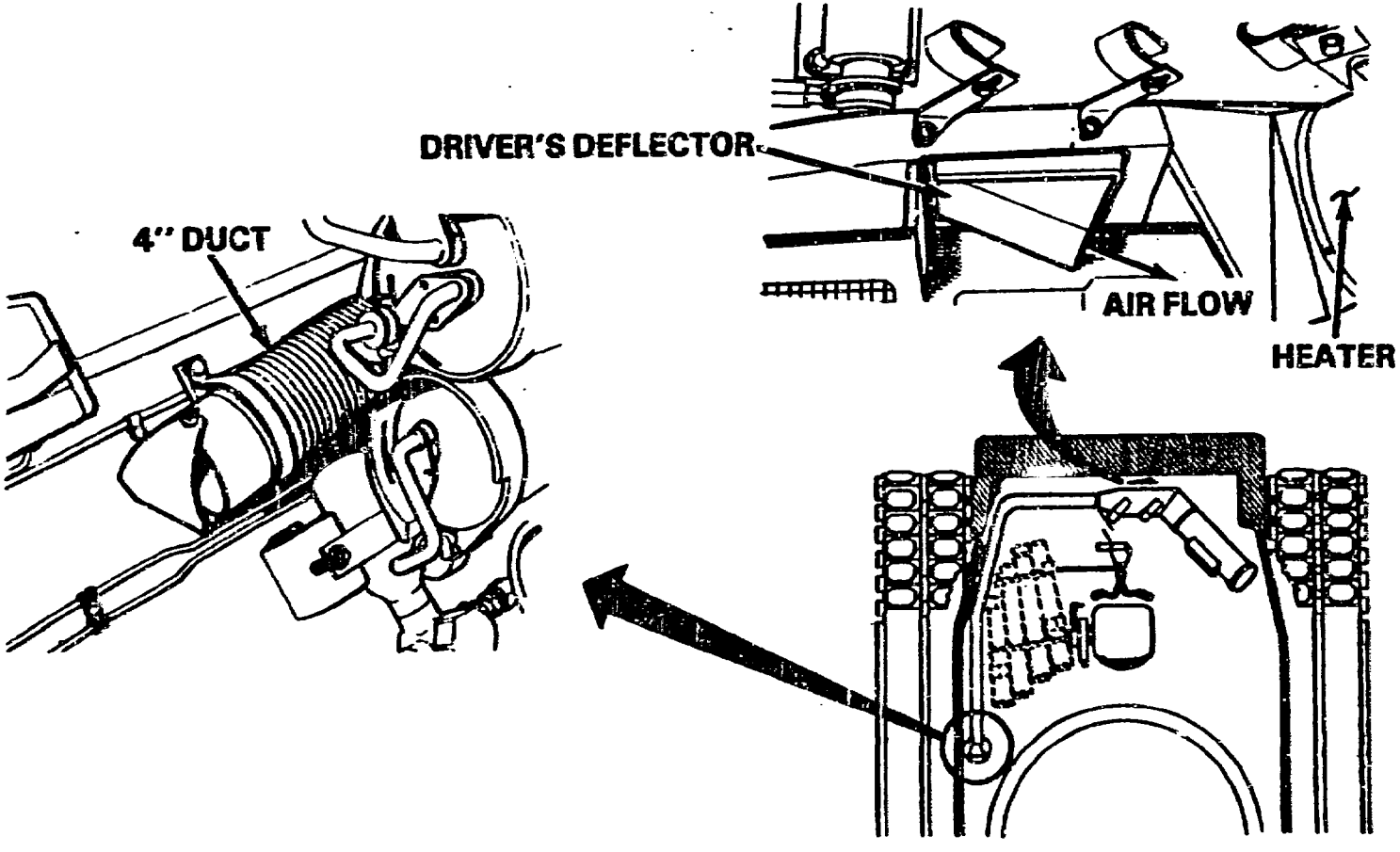


Figure 5-8.

5.2. Sample Size and Selection

The sample size was limited by the number of tanks which could be manned by 4-40 Armor. The "Blue" system was installed in ten tanks from A Company; the "Red" system on ten tanks in B Company; and the "Black" system on ten tanks in C Company. As the "Yellow" (DAVCO) system could only be applied to M60A1 RISE Passive or later model tanks, the nine "Yellow" systems were placed on three tanks from each company. Details concerning specific color coded systems by vehicle bumper number are shown below:

A COMPANY

BUMPER MARKING	TEST HARDWARE	TANK CONFIGURATION
A-11	Blue	AOS
A-12	Blue	AOS
A-13	Yellow	RISE Passive
A-15	Blue	RISE Passive
A-22	Yellow	RISE Passive
A-23	Blue	RISE Passive
A-31	Blue	RISE Passive
A-32	Blue	AOS
A-34	Yellow	RISE Passive
A-35	Blue	AOS
A-51	Blue	RISE Passive
A-65	Blue	RISE Passive
A-66	Blue	RISE Passive
13	10 - Blue 3 - Yellow	

B COMPANY

BUMPER MARKING	TEST HARDWARE	TANK CONFIGURATION
B-11	Red	RISE Passive
B-12	Red	AOS
B-15	Red	AOS
B-21	Yellow	RISE Passive
B-22	Red	AOS
B-24	Red	AOS
B-25	Red	AOS
B-31	Yellow	RISE Passive
B-32	Red	AOS
B-34	Yellow	RISE Passive
B-52	Red	AOS
B-65	Red	RISE Passive
B-66	Red	RISE Passive
13	10 - Red 3 - Yellow	

C COMPANY

BUMPER MARKING	TEST HARDWARE	TANK CONFIGURATION
C-11	Black	RISE Passive
C-12	Black	RISE Passive
C-15	Black	AOS
C-22	Black	RISE Passive
C-24	Black	RISE Passive
C-25	Black	AOS
C-31	Black	AOS
C-32	Black	RISE Passive
C-33	Yellow	RISE Passive
C-34	Yellow	RISE Passive
C-35	Yellow	RISE Passive
C-53	Black	RISE Passive
C-66	Black	AOS
13	10 - Black 3 - Yellow	

5.3. Test Hardware Installation

Test hardware was installed by a team of GDLS mechanics during the periods 7-17 December 1982 and 3-8 January 1983. PM-M60 Engineering representatives were on site to monitor the contractor's progress and provide an interface with the unit personnel. Numerous existing vehicle heaters were observed to be inoperative or completely missing. Existing components removed from the 39 test vehicles were placed in storage for reuse at test conclusion. The only special instrumentation installed was an hour meter on each test heater. Standard (Model "C") heaters were requisitioned by PM-M60 Logisitics and shipped from a depot direct to Ft. Carson. Of the 45 heaters, 29 were installed in vehicles and 16 were left at Direct Support (DS) maintenance as spares. Stewart-Warner shipped 15 prototype Model "A" heaters to Ft. Carson. Ten were installed in test vehicles and five were left at DS as spares. GDLS furnished all the remaining test hardware. Considerable difficulty was experienced by GDLS during the installation since the support systems were designed for an M60A3 tank. Numerous field design changes were required to adapt the hardware to the unit's M60A1 AOS and M60A1 RISE Passive vehicles.

5.4. Training.

Direct Support (704th Maintenance Bn) and General Support (DIO) maintenance personnel were issued technical manuals, trained on repairing the Model "A" heater and received refresher training on the Model "C" heater on 13 and 14 December 1982 by a joint GDLS, Stewart-Warner and TACOM Maintenance Directorate training team. DS personnel were briefed on the test data collection procedures, heater direct exchange guidelines and the chain of custody for failed components. Data collection forms and failed part tags designed at PM-M60 were distributed (see Test Design Plan - Appendix A). Crew and organizational maintenance personnel from the unit were issued technical manuals and received training on maintaining the various heaters and support systems on 15 and 16 December 1982 by the same training team. After the formal classroom presentation, the soldiers were shown the modified tanks in the motor pool. During the training class, the driver's data collection forms were distributed and explained. (See Test Design Plan - Appendix A).

5.5 Test Execution

5.5.1. General. This user test in an operational environment was arranged by direct coordination between PM-M60 Engineering and the 4th Infantry Division Maintenance Management Center (DMMC). Since the 4-40th Armor Battalion agreed to conduct the test as a "ride along" or "piggyback" to their regularly scheduled unit training activities, targets such as total test miles or total heater hours were not established. The measure-of-life units thought to be most significant for this test were total heater operating hours and total heater starts. Heater hours were measured by the hour meter. Heater starts were recorded by the vehicle crew members on data collection forms provided by PM-M60. The length of the test was cold weather limited. The test termination date of 23 March 83 was preselected to preclude contractor interference with the unit's major training activities (See Test Design Plan - Appendix A - for additional details).

A Memorandum of Understanding (MOU) was written between the PM-M60 Office and the DS maintenance unit to establish Direct Exchange (DX) procedures, a process for the return of failed parts and maintenance concepts. A copy of the MOU is attached with the Test Design Plan at Appendix A.

5.5.2. Vehicle Activity. The last of the 39 tanks selected for participation in the test was modified on 8 January 1983. On 10 January, Alpha Company moved to a field location where they were attached to an Infantry battalion for ARTEP training. The remainder of the battalion moved to the field on 16 January for similar training activities. The entire battalion returned to garrison on 24 January. February training included the Tank Crew Proficiency Course (TCPC), Sub-caliber Tables 1-5 and the Machine Gun Course. Each tank company used 3-4 vehicles for the February training and rotated all remaining crews through the same vehicles. March activity was primarily Annual Tank Gunnery Training (7-21 March). Although the unit discourages heater operation while in the motor pool, heater hours were accumulated on some vehicles between the major training exercises.

5.5.3. Liason Visits. Throughout the 3 month test, PM-M60 Test Group monitored test progress and recorded heater failures by conducting liaison visits to Ft. Carson once every three weeks. During these visits, Mr. Ashley and Mr. Fleetham collected failed components and completed data collection forms and returned them to Detroit. Crew members and maintenance personnel were interviewed and encouraged to report problems encountered and make recommendations for design improvements. Additionally, the Ft. Carson DARCOM Logistics Assistance Office (LAO) was thoroughly briefed on the test

and requested to visit the unit on a regular basis to monitor test progress and spot check unit compliance with the test plan. Several written and telephonic reports were sent from the Field Maintenance Technician (FMT), Mr. Justus, directly to the M60 Test Group.

After each liaison visit, Equipment Performance Reports (EPRs) were written by the PM-M60 Test Group. Copies were furnished during the test to GDLS, Stewart-Warner, the TACOM Heater Working Group and the PM-M60 Engineering Division. Abbreviated summaries of each EPR are attached to this report at Appendix F. Original EPRs are on file in the PM-M60 Office.

5.5.4. Test Support Package. A list of required spare parts to be stocked at Ft. Carson was compiled based on known Model "C" replacement part consumption rates and engineering estimates. Model "A" spare parts were furnished by Stewart-Warner. Model "C" spare parts were initially requisitioned thru the Army Supply System and those available were shipped direct to DS maintenance at Ft. Carson. Parts not available from the Supply System were obtained from Stewart-Warner. All heater repair parts were stocked only at DS with the exception of the igniter which was stocked at both the DS and organizational maintenance levels. Support system spare parts (prototype components only) were provided by GDLS and stocked in the unit motor pool at the battalion maintenance level.

5.5.5. Test Close-out Review. A meeting was conducted on 31 March 83 at the Battalion Headquarters to review the conduct of the entire test. Stewart-Warner, GDLS, PM-M60, and TACOM were present as well as numerous tank commanders, maintenance personnel and unit leaders. User concerns surfaced during the meeting are addressed in Section 5.9. of this report.

5.6 Test Hardware Removal

The test hardware was removed by a team of Anniston Army Depot (ANAD) mechanics during the period 23-31 March 1983. PM-M60 Engineering and GDLS representatives were on site to provide technical assistance, monitor progress, interface with the unit and record end-of-test condition of the heaters and support systems. The entire fleet of 39 test tanks were returned to their original heater and heater support system configuration (Model "C" heater with standard production support system). All except 5 of the hot air distribution systems on the tanks were returned to the 4" (standard production) configuration. The 5 remaining tanks are M60A1 AOS and are scheduled for conversion to M60A3 configuration at ANAD in the future. The 5" (improved design) hot air distribution systems will be replaced during the rebuild process at Anniston. Ample spare parts were left with the unit to maintain the 5" systems until that time. Before departing Ft. Carson, the ANAD team confirmed that every test tank had a functional heater system. Heater hour meters were removed and returned to the contractor. The 42 operational Model "C" test heaters remaining at the end of test (3 heaters were lost during the test) were left at Ft. Carson. Some were used to replace missing or inoperative heaters within the unit, some were donated to other units under the direction of the DMMC, and the remainder were left as spare heater assemblies to be used in the future at both the battalion and DS Levels. All remaining Model "C" heater spare parts were donated to DS maintenance. All Model "A" heaters and repair parts as well as all prototype support system spare parts were returned to GDLS. Most heater support system components removed from the vehicles were scrapped on site.

5.7 Analysis of Test Results

There are several ways to look at the data acquired in this test (starts, hours, miles, and failures for each system). In this paragraph, each of the several viewpoints is addressed, in order to determine whether the conclusions depend upon which method of analysis is used, or if the conclusions of the test are independent of the method of analysis. A summary of the raw test data appears in Table 5-1. Expanded data tables are attached at Appendix G.

		"BLUE" SYSTEM	"RED" SYSTEM	"YELLOW" SYSTEM	"BLACK" SYSTEM
Number of Test Vehicles		9	9	9	9
Heater Hours		2140	1309	1773	1322
Heater Starts		779	179	335	214
Hours/Start		2.7	7.3	5.3	6.2
Miles		2940	2080	2735	2678
Failures During Initial Installation	Heater	0	0	1C 1S	2C 2NC
	Support System	2NC	1NC	8NC	0
In-Service Failures	Heater	0	6C 6S	9C 2S 2NC	11C 2NC 2S
	Support System	2C 2NC	4C 1NC	1NC	3C
Total Failures (Chargeable)		6(2)	18(10)	24(10)	22(16)

C = Chargeable
NC = Not chargeable
S = Secondary failure

Table 5-1
Raw Test Data

5.7.1. System Comparison Considering only Chargeable Failures. For this test, a failure is defined as any incident that results in an unscheduled maintenance action requiring repair or removal of the heater or support system. Considering all chargeable failures of heaters or support systems, the following comparison is made:

	SYSTEM COLOR CODE			
	BLUE	RED	YELLOW	BLACK
Chargeable Heater Failures	0	6	10	13
Chargeable Support System Failures	2	4	0	3
Total Chargeable Failures	2	10	10	16
Mean Starts Between Chargeable Failures (MSBCF)	390	18	34	13
Mean Hours Between Chargeable Failures (MHBCF)	1070	131	177	83
Mean Miles Between Chargeable Failures (MMBCF)	1470	208	274	167

TABLE 5-2

System Comparison Considering All Chargeable Failures

The single most obvious result of the test is the very substantial reliability improvement demonstrated by the "Blue" system, consisting of the SW10660A heater, Engine Filter/Heat Tape support system, and Improved Design hot air distribution system. A comparison of test data from the other three systems using a method developed by the Army Material Systems Analysis Activity (AMSAA) for comparing two mean-times-between-failure for unequal test times, at the 10 percent level of significance, shows that there was no difference between the performance of the Engine Filter/Heat Tape support system and the standard support system during the Ft. Carson Test.

It is unfortunate that the SW10660A heater was not also tested with the standard heater support system. The number of tanks available for test precluded testing samples of each combination of heater and support system. The nominal sample size of ten tanks of each tested configuration was barely adequate for statistical analysis. In order to provide a sample of ten tanks in each configuration, sixty test tanks would have been required. However, it is possible to estimate the contribution of the Model "A" heater and the Engine Filter/Heat Tape support system to the success of the "Blue" tanks. As the "Red" support system was identical to the "Blue" support system, and since there was no statistical difference in performance between the "Red" (Engine Filter/Heat Tape) support system and the standard heater support system, the considerable improvement in reliability in the "Blue " tanks must be attributed to the Model "A" heater.

A comparison of the "Yellow" (DAVCO) system reveals only a marginal improvement in MSBCF and MHBCF, when compared with the "Black" (standard) or "Red" (Engine Filter/Heated Tape) systems. The performance of each of the other systems was far below that of the "Blue" system.

5.7.2 System Comparison Considering Heater Failures. A comparison of heater systems on test considering only chargeable heater failures results in the following table:

	SYSTEM COLOR CODE			
	BLUE	RED	YELLOW	BLACK
Chargeable Heater Failures	0	6	10	13
Mean Starts Between Chargeable Failures (MSBCF)	>>779	30	34	16
Mean Hours Between Chargeable Failures (MHBCF)	>>2140	218	177	102
Mean Miles Between Chargeable Failures (MMBCF)	>>2940	348	274	206

>> = much greater than since there were no failures

TABLE 5-3

System Comparison Considering Only Chargeable Heater Failures

The above table is probably the data which can be most easily compared to heater specification testing, as only chargeable heater failures are considered.

In a similiar manner, considering all heater failures, whether chargeable, not chargeable, or secondary, results in the following:

	SYSTEM COLOR CODE			
	BLUE	RED	YELLOW	BLACK
Total Heater Failures	0	12	15	19
Mean Starts Between Operational Mission Failures (MSBOMF)	>> 779	15	22	11
Mean Hours Between Operational Mission Failures (MHBOMF)	>> 2140	109	118	70
Mean Miles Between Operational Mission Failures (MMBOMF)	>> 2940	174	182	141

>> = much greater than since there were no failures

TABLE 5-4

System Comparison Considering All Heater Failures

An analysis of the results obtained above shows that, at a 10 percent level of significance, there is no difference between the performance of any of the support systems. The dramatic improvement in performance by the "Blue" system can therefore be attributed solely to the performance of the Model "A" heater.

5.7.3 System Comparison Considering All Failures. Normally, failures are categorized as chargeable or non-chargeable depending on whether the incident was caused primarily by a hardware failure, or primarily by a maintenance or operator error. Traditionally, non-chargeable failures are not counted in the analysis process, if they would not have occurred had the operator or maintenance error not occurred. However, it may be useful to compare systems including these "non-chargeable" failures, as the hardware will have to function in a soldier environment. If failures occur due to operator or maintenance errors, they count just the same as "chargeable" failures to the operator/crew and maintenance personnel. Because there is no way to control operator/maintenance errors, there may not be an even distribution among the test configurations. On the other hand, if it can be shown that one or another system on test can deal successfully with one or more categories of operator or maintenance error, then a comparison including these failures is appropriate. In a similar manner, it may not be appropriate to totally ignore so-called "secondary" failures. The rationale for disregarding secondary failures is that "there was really only one failure; the secondary failures merely show that the soldiers were treating the symptoms, rather than the cause of the failure." While it may be technically true that only one failure occurred, if the soldiers did not recognize the source of the failure, the test item may have oscillated in and out of service for the whole test, all on account of one failure. As far as the user is concerned, each time the item becomes non-operational, a failure has occurred and maintenance is required. If it can be shown that one or another system on test can deal successfully with "secondary" failures, then a comparison including these failures is in order. In a number of incidents on each of the Red, Yellow, and Black systems, a non-chargeable failure of a heater or support system resulted in the secondary failure of igniters and/or ignition controls. The following examples illustrate the point:

- EPR C021, tank B65 (Red System, Model "C" heater): After three igniters were burned out over a one month period, the heater failed again and was replaced. During checkout at DS maintenance, foreign material (suspected to be pieces of teflon tape used to seal joints in fuel lines) was found to be blocking the inlet fuel screen of the fuel regulator valve. The flame detector switch was found to be out of adjustment, indicating that a crewman may have attempted to get the heater to run by adjusting the flame detector switch. The igniter and ignition control were burned out, probably as a result of the heater's failure to start over a long period. The piece of teflon tape in the fuel was an installation error which caused the (non-chargeable) failure of the igniter, ignition control and flame detector switch. Three previous igniter failures were secondary failures. Had the teflon tape blocked the fuel inlet screen on a Model "A" heater, it may also have failed to start. However, there is substantial evidence to show that the failure to start would not have resulted in secondary failures. The Model "A" heater incorporates a design feature to shut itself off if it has not started within two minutes. EPR C012 on tank A31 (Blue system) placed a Model "A" heater in similar circumstances. In this case, the fuel shutoff valve was inadvertently left in the closed position, preventing the flow of fuel to the heater. Instead of numerous secondary failures, the only result was that the heater failed to start. No parts were burned out, not even an igniter. When the fuel shutoff valve was opened, the Model "A" heater ran properly.

- EPR C066, C022, C069, and C047 on tank B24 (Red system, Model "C" heater): Three igniters, an ignition control, flame detector switch, and a burner/wick were replaced as a result of three secondary failures and the primary failure of a heater fuel pump. (The fuel pump was shorted, which precipitated the other failures). Again, in a virtually identical situation, EPR C046 on tank A65 equipped with the Blue system, Model "A" heater, shows that when the fuel pump was replaced on A65 the Model "A" heater ran properly. Again no heater parts were burned out, not even an igniter.

- EPR C036, tank C34 (Yellow system, Model "C" heater): This heater failure is listed as "Non-chargeable" because the tank commander told a contractor representative that he believed that the flame detector switch could be used as a thermostat and fan speed selector switch by which he could regulate the heater output. The unauthorized tampering with the flame detector switch eventually resulted in a heater failure. This type of failure did not occur on the Model "A" heater because the flame detector switch has been replaced with a solid state flame sensor assembly which does not have an obvious adjustment screw like the flame detector switch.

The examples given above indicate that it may be appropriate to compare each of the test configurations including all failures, whether chargeable, non-chargeable, or secondary, in order to determine a measure of operational reliability which would include the combined effects of item design, quality, installation, environment, operation, maintenance, and repair. The measures will be called Mean-Hours-Between-Operational-Mission-Failures (MHBOMF), and Mean-Starts-Between-Operational-Mission-Failures (MSBOMF). The following table provides a summary of the appropriate data:

	SYSTEM COLOR CODE			
	BLUE	RED	YELLOW	BLACK
Total Heater Failures	0	12	15	19
Total Support System Failures	6	6	9	3
Total Failures	6	18	24	22
Mean Starts Between Operational Mission Failures (MSBOMF)	130	10	14	10
Mean Hours Between Operational Mission Failures (MHBOMF)	357	73	74	60
Mean Miles Between Operational Mission Failures (MMBOMF)	490	116	114	122

TABLE 5-5

System Comparison Considering all Failures
(including non-chargeable and secondary failures)

Again, there is no significant difference in the performance of any of the support systems, so the substantial increase in MHBOMF/MSBOMF/MMBOMF must be attributed to the Model "A" heater.

5.7.4. System Comparison Considering Only In-Service Failures. It may be argued that including initial failures in the test data analysis may bias the test results, as many of these failures indicate quality problems in the manufacturing process.

During the initial installation of the test hardware by GDLS, 4 of the 29 new Model "C" heaters failed to operate in the vehicle. These 4 heaters had to be replaced and repaired at DS maintenance. A Quality Deficiency Report (QDR) was initiated by the Ft. Carson LAO. The Stewart-Warner response attributes the failures to installation errors. The responsible DCASMA concurred with the contractor's findings, however, the TACOM Directorate for Product Assurance still contends some of the failures are quality related.

While these problems may tell us something about the quality of the production heater, they probably do not relate very well to the engineering design of the heater. There were also 4 recorded cases in which the "Yellow" (DAVCO) System interfered with setting the pack, and 3 cases in which the "Yellow" (DAVCO) fuel lines were pinched, preventing fuel from flowing to the heater. This is definitely a design problem; however, it may be useful to know what the reliability of the heater would have been had such interference not occurred. This approach assumes that the DAVCO system could be redesigned for better fit without changing its performance. The following tables are the result of eliminating all initial installation failures, considering only failures "in service" after all heaters and support systems had been successfully installed and checked out.

	SYSTEM COLOR CODE			
	BLUE	RED	YELLOW	BLACK
Total In-Service Heater Failures	0	12	13	15
Total In-Service Support System Failures	4	5	1	3
Total In-Service Failures	4	17	14	18
In-Service Mean Starts Between Operational Mission Failures (MSBOMF)	195	11	24	12
In-Service Mean Hours Between Operational Mission Failures (MHBOMF)	535	77	127	73
In-Service Mean Miles Between Operational Mission Failures (MMBOMF)	735	123	195	149

TABLE 5-6

System Comparison Considering All Failures "In-Service"
(Eliminating Failures During Initial Installation)

	SYSTEM COLOR CODE			
	BLUE	RED	YELLOW	BLACK
In-Service Chargeable Heater Failures	0	6	9	11
In-Service Chargeable Support System Failures	2	4	0	3
Total In-Service Chargeable Failures	2	10	9	14
In-Service Mean Starts Between Chargeable Failures (MSBCF)	390	18	37	15
In-Service Mean Hours Between Chargeable Failures (MHBCF)	1070	131	197	94
In-Service Mean Miles Between Chargeable Failures (MMBCF)	1470	209	304	191

TABLE 5-7

System Comparison Considering Only Chargeable Failures Occurring "In-Service" (Eliminating Failures During Intitial Installation and Non-Chargeable Failures)

Once more, no difference is seen between any of the support systems at a 10 percent level of significance, for the data presented in Table 5-6 or 5-7 above.

5.7.5. Test Data Acquisition in Alpha Company. A review of the test data will reveal that the "Blue" system acquired far more miles, hours, and starts than any other system. There are several reasons for this.

1. First, Alpha Company spent seven more days in the field than the other companies. Over the period of the Winter Test, this equates to about 30 percent more field time than the other companies. As the vast majority of hours, starts, and miles were achieved in the field, it is understandable that Alpha Company would therefore acquire more test data, regardless of the heater system on test.

2. The second reason for the large number of hours and starts in A Company is simply that, because there were no failures, the heaters were available for use by the soldiers. In both other companies there were a number of failures which occurred during the field problems. Most failures in the field resulted in non-availability of the heater for several days. Repair of the failures which occurred after the mid-point of the field exercise tended to be deferred until the unit returned to home station, due to the natural emphasis on the unit's primary mission.

3. One more reason for the large number of starts in Alpha Company is apparent from a review of crew data forms. Especially after the first few days, tank crews in A Company gained so much confidence in the heater that they were willing to turn the heater on when the tank got cool, and shut it off when the tank got warm. In contrast, crews with any of the other heater systems had little confidence that heaters would restart. The preconception that frequent starting is a major contributor to heater failure was overcome quickly in A Company but not in other companies. In a number of cases, once the heaters were successfully started, crews were reluctant to turn them off for any reason. Many heaters were run continuously for 12-18 hours per day, and several were run 24 hours per day until they failed. Some crews even removed their shirts and boots rather than risk having to restart heaters.

5.7.6 Test Data Acquisition in Bravo Company. Although it can be argued that the low number of hours and starts achieved in Bravo Company as compared with Alpha Company may be related to the difference in operational availability of the heater, this argument is clearly not applicable to a comparison between B and C Companies. For some reason, B Company failed to acquire as many miles or starts as C Company, even though there were fewer failures. The relatively low MHBF/MSBF/MMBF achieved by the "Red" system is due primarily to the low number of hours, starts, and miles acquired, rather than a high number of failures compared with other systems.

5.7.7. Summary. It is apparent that no matter how the test data is viewed, the same conclusions must be reached: (1) The Model "A" heater demonstrated vastly superior reliability in terms of hours and starts between failures, and (2) no substantial difference is noted between the various support systems tested.

5.8. Test Limitations.

This test had several limitations which should be noted before irrevocable decisions are made regarding both heaters and support systems.

First, the daily temperatures did not go low enough to test the ability of the support systems to deal with parrafin clouding, or "waxing". (See temperature data Appendix D). Although crew members universally stated that it was "very cold" during their field training and that having an operational heater made a great deal of difference to them, it cannot be said that weather conditions tested heater support systems severely. It is entirely possible that, under more severe conditions, either of the Engine Filter/Heat Tape or DAVCO systems, or both, might have demonstrated an ability to deal with waxing. A cold chamber laboratory test has been designed to test the Engine Filter/Heat Tape support systems under controlled conditions which will include various concentrations of water contamination of the fuel. Temperature will be sufficiently low to cause freezing of water in the fuel and waxing of the fuel itself.

A second limitation of the test is that each Model "A" heater averaged 238 hours of operation with no failures. Only two Model "A" heaters accumulated over 400 hours of operation. This indicates that we have seen only the "infant mortality" and part of the flat portion of the bathtub curve representative of the "Blue" heater system reliability. Based upon this and previous heater tests, it appears that the normal heater use is about 200 hours for a three month midwinter period in a temperate climate. The only way to see the whole curve would be to test longer, perhaps over a two year period, to test in an Arctic Environment, or to test in a laboratory. In contrast, even though there were far fewer hours accumulated on each Model "C" heater, we have probably seen the whole Model "C" heater curve, as there were several failures per vehicle on these tanks.

A final limitation is that while all heaters tested at Ft. Carson were brand new, the 10560C heaters were production heaters, while the 10660A heaters were prototype heaters. While this situation could not be avoided, it is felt that a comparison of systems considering only "in-service" failures would tend to eliminate any bias resulting from differences between prototype and production heaters. This comparison has been made in paragraph 5.7.3 above, and shows the same trends noted earlier.

5.9. User Concerns

During the periodic liaison visits to Ft. Carson, unit personnel mentioned various observations, concerns and recommendations involving the heater and support sytems. Each of these items were discussed in detail during the test close-out review conducted on 31 March 1983 (See Section 5.5.5.). A summary of the current status of each concern is shown below.

- Fuel Consumption. There was a widespread perception in the chain of command that test heaters of all types burned more fuel than normal. This may have been a result of the incorrect assumption that since the "Blue", "Red", and "Yellow" systems had larger fuel lines, they would burn more fuel. While there are probably other factors involved, the continuous running of heaters must have contributed to high fuel use. As noted earlier, the draft heater specification includes a change to the fuel consumption rate. The qualification test will show conclusively whether the heater fuel consumption is within requirements. The battalion commander concluded during the close-out review that this item was no longer a user concern.

- Fire Extinguishers. All three tank companies reported occasional discharge of both the fixed and portable vehicle fire extinguishers (See Tank Crew Exit Survey Results - Appendix B). The air duct on the improved design hot air distribution system extends 12" closer to the portable fire extinguisher (stowed in a floor bracket beside the loader's feet) when the gun tube is over the front of the tank. This close proximity of the hot air duct causes the 2-3/4 lb. halon portable fire extinguisher to discharge. Some tank commanders avoided this condition by placing the portable fire extinguisher in the oddment tray. The stowage location on the M60A3 tank has been changed to avoid this problem which had been previously reported by the field on the standard heater duct. In order for the fixed fire extinguisher to discharge due to heat alone, specifications require the contents of a properly filled bottle to reach 135°F under worst case conditions before discharge. Several crews reported continous heater operation during field training including periods when the hatches were closed and the tank was not occupied. This mode of operation could cause the fixed fire extinguisher to discharge. After subsequent questioning of the crews, several discharges initially attributed to overheating were determined to have been a result of other circumstances. For example: on vehicle A51 a mechanic accidentally discharged the portable fire extinguisher by stepping on it; the fixed fire extinguisher on B21 was improperly secured in the vehicle and discharged when it was knocked over; the discharge of the fixed fire extinguisher on A32 occurred prior to the installation of the test hardware and was attributed to a hole in the hot air duct near the fire bottles.

- Heat Distribution - Driver's Compartment. The improved design air distribution system includes a revised driver's deflector (See Figure 5-7). Numerous tank drivers complained that the hot air blew directly on their boots causing their

feet to sweat. Once they were outside the tank in snow and/or low temperatures, their wet feet were susceptible to cold injury. They recommend a design change to direct the hot air against the driver's chest. This recommendation is currently being studied by PM-M60 and GDLS.

- Maintenance Allocation Chart (MAC). Approximately 50% of the crew members surveyed believed they should be allowed to perform limited heater maintenance themselves (see Tank Crew Exit Survey Results - Appendix B). Organizational mechanics recommend that adjustment and/or replacement of the flame detector switch should be authorized at their level. These suggestions require changes to the MAC and the PLL/ASL authorizations. TACOM Maintenance Directorate is currently studying this issue.

- Continuous Heater Operation. Several tank commanders indicated that their past experience with unreliable heaters has convinced them that heater failures are a function of total heater start attempts. The final test report on the Ft. Knox and CDI heater tests conducted during the winter of 1980-81 also indicates that heater cycling is a primary cause of heater mortality. This belief has propagated directions to the tank drivers that once a heater starts successfully, it should not be turned off for fear it may not restart when needed. Crew members reported instances where test heaters were operated continuously for periods of 18-24 hours. This user perception can only be changed by crew exposure to heaters with greater reliability in the future.

- Frequent Igniter Replacement. The user frequently attributes heater failure to failed igniters. This perception is based on the documented extremely high replacement rate for igniters in the current production (Model "C") heater. The results of the EPR close-out conference conducted on 5 May 1983 (See Appendix F) indicate that igniter failures are quite often merely a symptom of another undiagnosed fault. A long starting cycle associated with a blocked fuel supply line, low vehicle battery voltage, etc. will result in a secondary failure of the ignition circuit, usually manifested by a shorted igniter.

- Power Pack Interference. Nearly every crew associated with the DAVCO support system (Yellow) reported difficulty installing the power pack due to an interference condition between the engine primary fuel filter and oil cooler lines with the heater fuel pump and fuel lines. This design deficiency is acknowledged and the heater fuel pump will be relocated in the event further development of this support system concept is warranted in the future.

- Heater Fuel Filter Drain Valve. The Engine Filter/Heat Tape support system (Blue and Red) incorporates a manual drain valve on the bottom of the heater fuel filter cannister in the driver's compartment. Many crew members who attempted to use the valve found inadequate clearance for a container to catch the water. Water was drained directly onto the floor in the driver's compartment. This design deficiency has been acknowledged and will be resolved in the event further development of this support system is warranted in the future.

- Formal Army Heater Maintenance Training. Maintenance personnel at DS and organization complained about insufficient formal heater repair training during Advanced Individual Training (AIT). Troubleshooting and repair techniques are reportedly learned by means of On-The-Job-Training (OJT) in the field. According to the Ordnance School at Aberdeen Proving Grounds, the 63G10 (DS Fuel and Electric Repairman) receives a total of 9 hours

of instruction on repair of vehicle fuel burning personnel heaters during the 8 week course. Five hours are devoted to heater repair, 3 hours address testing, and the remaining hour consists of a performance exam. The Armor School at Fort Knox reports the 63N10 (M60A1/A3 Tank Systems Mechanic) receives a total of 2 hours of instruction on troubleshooting the personnel heater electrical circuit during the 9 week course. Training is not conducted on troubleshooting the heater fuel supply or heater repair.

- Serviceability of Adjacent Components. Isolated complaints of accessibility problems during routine maintenance on the tank master cylinder and gas particulate filter were discussed. GDLS is investigating the problem and will propose design changes if required.

- Heater Combat Essential? Field reports indicate that in cold weather certain elements of the fire control system will not work without an operational heater. Based on this fact, some soldiers requested that the heater be made a combat ready reportable item. A DA Form 2028 was submitted requesting this change. To date no action/decision has been made; however, making the heater combat essential would seem uncalled for considering the redundant sighting systems available to tank crewmen.

5.10. Logistics Implications

5.10.1. Validation of Maintenance Concepts. The test revealed that organizational maintenance personnel were not capable of effectively maintaining their heaters. Conversations with unit personnel and subsequent interviews with other Army personnel familiar with heater maintenance, confirmed that the 4-40 Armor's heater maintenance shortcomings are universal throughout the Army. These shortcomings appear to be caused by the following factors:

- An operational heater is not combat essential. Organizational maintenance personnel focus their efforts at quarterly service and in the field on keeping their tanks combat ready. To them, an operational heater is a luxury that can be ignored. In short, little incentive exists for unit maintenance personnel to repair heaters.

- Organizational maintenance personnel did not know how to repair heaters. During the pretest classes, a substantial majority stated they had never received any training on repairing heaters. (See section 5.9.)

- Although special manuals were provided for the test, the current TMs do not cover all the heaters used in M60 tanks, further discouraging mechanics from maintaining heaters.

- Replacement parts to repair heaters are difficult to keep stocked in the field. The monthly demands are quite high and depots are often out of stock.

This lack of effective organizational heater maintenance forces the operators to maintain their own heaters if they want to stay warm. The option of obtaining a replacement heater is a poor one for operators because the "direct exchange" process (DX) often takes a number of days. Operator heater maintenance often creates as many problems as it solves. The operators lack training, manuals, and parts support, so not surprisingly, they simply do not know what they are doing when they work on a heater.

The test proved that DS maintenance can maintain a volume of heaters provided that parts, training, manuals, and heater test stand are available. SP4 Paulson, the DS heater repairman, received no formal training until the test. Although contractors stated that SP4 Paulson did not always apply the proper procedure, he performed admirably and skillfully. One must remember that he was responsible for all the heater maintenance at Ft. Carson last winter.

Although GS Maintenance personnel were trained for this test, they did not repair any heaters.

Organizational maintenance will have to get into the heater repair business or heater maintenance at the unit level will not improve. Given the fact that the heater is not combat essential, little improvement seems likely. 4-40 Armor personnel requested TACOM to approve heater maintenance at the operator level, but this solution is not tenable. Proper heater maintenance is nearly impossible without a multimeter. Issuance of mulimeters to operators is not foreseen in the near or distant future. The current heater maintenance concept of concentrating heater repair at DS maintenance will not change. Introduction of a heater like the 10660A will not alter this concept.

5.10.2. Heater Test Stand. The test underscored the essentiality of a heater test stand in a DS shop. The 704th Maint BN's crude, homemade stand required modification to operate the 10660A heater. After modification to include some new capacitors, the stand did the job. Unfortunately, most units lack the luxury of any stand. A repairable test stand accompanied with checkout procedures for different heaters would certainly increase the efficiency of DS shops Army wide. Steps are being taken within TACOM to make such a stand available for field use.

5.10.3. Test Manuals. GDLS prepared crew, organization, and DS/GS repair manuals for each of the four unique test configurations. The manuals were given wide distribution at Ft. Carson during test hardware installation and were incorporated into the training classes. However, based on interviews with crew members and maintenance personnel, the manuals were not used enough during the test to evaluate their adequacy.

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Mioduski, Robert E., "Tables for Comparing Two Mean-Time-Between-Failures (MTBFs) for Unequal Test Times", U.S. Army Materiel Systems Analysis Activity Technical Report #226, April 1979.

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APPENDIX A

TEST DESIGN PLAN

AND

MEMORANDUM OF UNDERSTANDING (MOU)

FT. CARSON HEATER TEST

TEST DESIGN PLAN

1 DECEMBER 1982

I. INTRODUCTION

A. Purpose and Scope of Test.

1. Purpose of Test: This test will compare new and current production tank heaters and associated support hardware in an operational environment.

2. Test Objectives:

a. To determine whether the SW 10660A heater provides substantial reliability improvement over the SW 10560C heater.

b. To determine whether the proposed "engine filter" heater support system contributes substantially to heater system reliability with either heater.

c. To determine whether the proposed "DAVCO" heater support system contributes substantially to heater reliability.

3. Configuration: Tanks within the 4-40 Armor Bn, 3d Bde, 4th Inf Div (Mech) will be configured as follows:

10 tanks with 10660A heaters and "engine filter" heater support systems. (BLUE)

10 tanks with 10560C heaters and "engine filter" heater support systems. (RED)

9 tanks with 10560C heaters and "DAVCO" heater support systems. (YELLOW)

10 tanks with 10560C heaters and standard heater support systems. (BLACK)

4. Definitions:

a. SW 10660A heater: A new design 60,000 BTU tracked vehicle heater with features designed to overcome problems experienced with past heaters. This heater is capable of operation in the "dual air" mode to provide tank crews heat while the tank is "buttoned up" for tactical or NBC reasons. (This feature will not be tested).

b. SW 10560C heater: The current production 60,000 BTU heater for M60/M48 series tanks.

c. Heater Support System: The hardware required for integration of the heater into the tank. These parts typically consist of fuel lines, heater fuel pumps and filters, hot air ducting, and controls.

d. "Engine Filter" Heater Support System: Fuel lines consisting of 5/8" diameter tubing, 3 feet of which is heated; flexible fuel hose; a 40 micron filter with manual dump in the driver's compartment; a heater fuel pump; and a 5" diameter hot air duct with revised driver's vent.

e. "DAVCO" Heater Support System: A heated fuel-water separator with automatic dump and a fuel pump in the engine compartment; fuel lines consisting of 5/8" diameter tubing and flexible hose; and a 5" diameter hot air duct.

5. Scope and Tactical Context: Each of the tanks listed in paragraph 3 above will be operated by 4-40 Armor as required by their training schedule. No specific scenario of operation is required. It is desired that each of the sets of differently configured tanks operate in similar training and climatic conditions and that each tank acquire as many hours and miles of operation as possible, consistent with the training schedule.

6. Milestones:

Test hardware installed	7-17 Dec 82	
Traning of DS/GS Maint. Personnel	13-14 Dec 82	
Training of Crews and Org. Maint Personnel	15-16 Dec 82	
Start of Test	20 Dec 82	(3 Jan 83)
Liaison Visit	5 Jan 83	
Liaison Visit	26 Jan 83	
Liaison Visit	19 Feb 83	
Liaison Visit	9 Mar 83	
End of Test	23 Mar 83	
Removal of Test Hardware	23-31 Mar 83	
Test Close-out Review	30 Mar 83	
Final Test Report	25 Apr 83	

B. Background:

1. History: Past experience with tank heaters has shown that in some cases, heaters perform well on qualification tests but fail to measure up to prolonged field usage. In fact, the heater has been the number one contributor to M60A3 reliability. According to sample data collection from Europe, over 10% of all vehicle incidents relate to the heater. In order to increase the reliability of tank heaters in the field, several changes have been made to the heater itself, and several major modifications have been developed for the heater's support system.

2. Issues for Test:

a. Critical Issues.

(1) Does the SW 10660A exhibit substantially higher MMBF/MSBF than the SW 10560C with an identical support system?

(2) Does the "DAVCO" heater support system provide substantially longer MMBF/MSBF than the "engine filter" heater support system?

(3) Does either the "DAVCO" heater support system or the "engine filter" heater support system provide substantially longer MMBF/MSBF than the standard heater support system?

(4) Do any of the configurations provide an equivalent of 600 hours MTBF? (With burner replacement permitted at 400 hours). This MTBF is a requirement of the new heater specification.

b. Other Issues.

(1) What are the failure modes of the SW 10650A? The SW 10560C? How do they vary with support system used?

(2) Is the SW 10660A more/less maintainable than the SW 10560C?

(3) Does either the "DAVCO" Heater Support System or the "engine filter" heater support system provide maintainability benefits/drawbacks compared to the standard system?

(4) Are any safety hazards introduced or eliminated by any of the new heaters or support systems?

(5) To what extent does any of the test hardware correct the human factors inherent in the current heater system?

(6) Are draft manuals adequate?

II. TEST CONDITIONS

A. Tanks will be operated normally, as required by the unit. No special test conditions are required. Each tank and heater should acquire as many hours/miles of operation as possible, consistent with the unit mission.

B. All heater maintenance will be performed by the applicable level of maintenance IAW draft manuals.

III. CONDUCT OF TEST

A. Installation: Installation of heater support systemss will be done by contractor representatives with equipment and facility support from the unit. All heaters, including the standard SW 10560C will be provided new by PM-M60. The test unit will install all heaters. Contractor representatives will make a final checkout prior to operation. The test unit is required to store heaters and support systems removed.

B. Training: Training will be provided by a contractor team to ensure that drivers and maintenance personnel are aware of any special operational or maintenance procedures prior to start of test.

C. Test Hardware Segregation: It is imperative that each tank/heater/heater support system remain pure. In order to prevent accidental mixing of heaters and parts, all heaters and installation systems will be painted and tagged prior to delivery IAW the color scheme shown in paragraph 3 above.

D. Actions Required of Drivers: Blank forms will be provided for drivers and organizational maintenance (Incl 1), and for DS maintenance (Incl 2). On each day of operation, drivers will enter the date and make a tick mark for each time the heater is started. The same form will be used until the form is completely filled out or the heater requires repair. When this happens, the driver will enter a large "X" next to the date, and will notify organizational maintenance.

E. Actions Required of Organizational Maintenance: The organizational maintenance mechanic will remove the heater and fill out the reverse side of the driver's form. If repair is beyond the capability of organizational maintenance, the heater and form will be DX'd at DS Maintenance. Heaters will not be accepted for DX without a form with both sides filled out. Any failed parts removed from a test heater will be tagged IAW Incl 3 and stored for subsequent pick-up by a TACOM representative. Forms will be retained for pick-up by the TACOM representative.

F. Actions Required of DS/GS Maintenance: When heaters are repaired at DS/GS Maintenance, the mechanic performing the repair will fill out a second form (Incl 2) and staple it to the driver/organizational mechanic form. Any failed parts removed from a test heater will be tagged IAW Incl 3 and stored for subsequent pick-up by a TACOM representative. Forms will be retained for pick-up by the TACOM representative. Unrepairable heaters will be tagged and stored similar to failed parts.

G. Test Support Package: A 50% overage of each type heater will be provided for DX, as well as well as a suitable supply of repair parts. Additional repair parts/heaters may be requested through PM-M60.

H. Liaison Visits: About every three weeks, a TACOM representative will visit the test unit and DS Maintenance facility. All filled out forms and tagged failed parts will be collected at this time for subsequent return to manufacturer for failure analysis.

I. Test Close-out Review: After the completion of the test, a test close-out review will be held at the test unit. Representatives from PM-M60, TACOM, General Dynamics, and Stewart Warner will meet with unit and DS/GS Maintenance representatives to review data collected, conduct a questionnaire sampling from unit and DS/GS Maintenance personnel, and receive the comments of the chain of command relative to the performance of the test hardware. Copies of the final test report will be provided to the test unit and contractors.

J. Removal of Test Equipment: At the end of the test, all 10660A heaters and support systems will be removed and replaced with 10560C heaters and support systems provided by the test unit. All heater support systems will be returned to "as delivered" status by contractor representatives.

K. Contractor Representatives: Except for installation, checkout, failure analysis, test close-out review, and final removal of hardware, contractors will not have access to the test unit or hardware.

IV. DATA REQUIREMENTS AND ANALYSIS LOGIC

Comparisons will be drawn in order to answer the list of issues given in paragraph I.B.2 above.

A. Issues a(1) through (4) (Reliability Comparisons) will be answered based upon a comparison of system Mean Miles Between Failures (MMBF) and Mean Starts Between Failures (MSBF). A failure will be charged each time the heater or a component of the heater support system is removed from the tank for maintenance (except for preventive maintenance).

1. Miles on teach tank will be collected at the beginning and end of the test. The total mileage of tanks in each heater configuration will be divided by the total failures to arrive at MMBF.

2. The total number of starts for heaters of each configuration (from a compilation of drivers forms) will be divided by the number of failures to arrive at MSBF.

3. An attempt will be made to make a subjective estimate of heater hours based upon days operated, daily maximum and minimum temperatures as recorded at the airfield, number of starts, and type of training conducted.

B. Issue b.(1) (Failure Modes) will be answered using data compiled from organizational maintenance and DF maintenance forms, as well as failure analyses conducted by contractors.

C. Issues b.(2) and (3) (Maintainability), as well as Issue b.(4) (Safety), (5) (Human Factors), and (6) (Adequacy of Draft Manuals), will be answered through questionnaires, interviews, and the compilation of comments in the "Remarks" block of forms.

DRIVER'S RECORD FOR PERSONNEL HEATER

VEHICLE BUMPER NUMBER _____

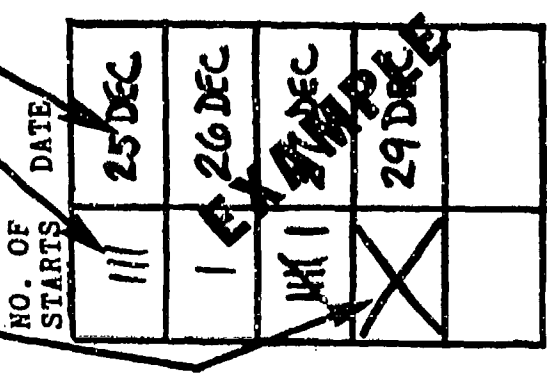
COLOR OF HEATER _____

HEATER SERIAL NUMBER _____

DRIVER: EACH DAY YOU START THE HEATER, WRITE THE DATE IN THE BOX HERE AND PUT A SLASH HERE FOR EACH TIME YOU START THE HEATER.

IF YOUR HEATER DOESN'T WORK, WRITE THE DATE IN THE BOX AND PUT A BIG X HERE.

GET YOUR COMPANY MAINTENANCE TO DX THE HEATER FOR YOU. YOU MUST TURN IN A FILLED-OUT FORM WITH THE HEATER! NATURALLY, YOU'LL HAVE TO START A NEW FORM WHEN YOU GET A NEW HEATER.



DATE													
NO. OF STARTS													

DATE													
NO. OF STARTS													

INCL 1

IF YOU RUN OUT OF SPACE, USE A NEW FORM AND SAVE THIS ONE TO TURN IN WITH IT.

ORGANIZATIONAL MAINTENANCE FOR PERSONNEL HEATER

DATE OF REPAIR: _____ HOURS (Read from Meter) _____

1. PROBLEM IDENTIFICATION:

   A. Heater Won't Start

   - ☐ Flooded
   - ☐ Weak Battery
   - ☐ No Fuel
   - ☐ Other (Describe) _____

   _____

   _____

   B. ☐ Low Heat Output

   C. ☐ Heater Overheats

   D. ☐ Support System Malfunction

2. PROBLEM RESOLUTION

   A. ☐ Repaired Heater or Support System

   Describe Action: _____

   _____

   _____

   _____

   B. ☐ Replaced Heater

3. REMARKS:

FOR PERSONNEL HEATER MAINTENANCE

1. HEATER IDENTIFICATION:

HEATER SERIAL NUMBER_____ HOURS (READ METER)_____

STEWART WARNER 1066A ☐ HUPP 510B ☐

STEWART WARNER 10560C ☐ STEWART WARNER 10560M ☐

2. HEATER REPAIR

PURGED FUEL ☐ ADJUSTED SWITCHES ☐

PURGED WATER ☐ CLEANED FUEL LINES ☐

RECONNECT ELECTRICAL ☐ ADJUSTED FUEL FLOW ☐

OTHER_____

3. PARTS REPLACEMENT

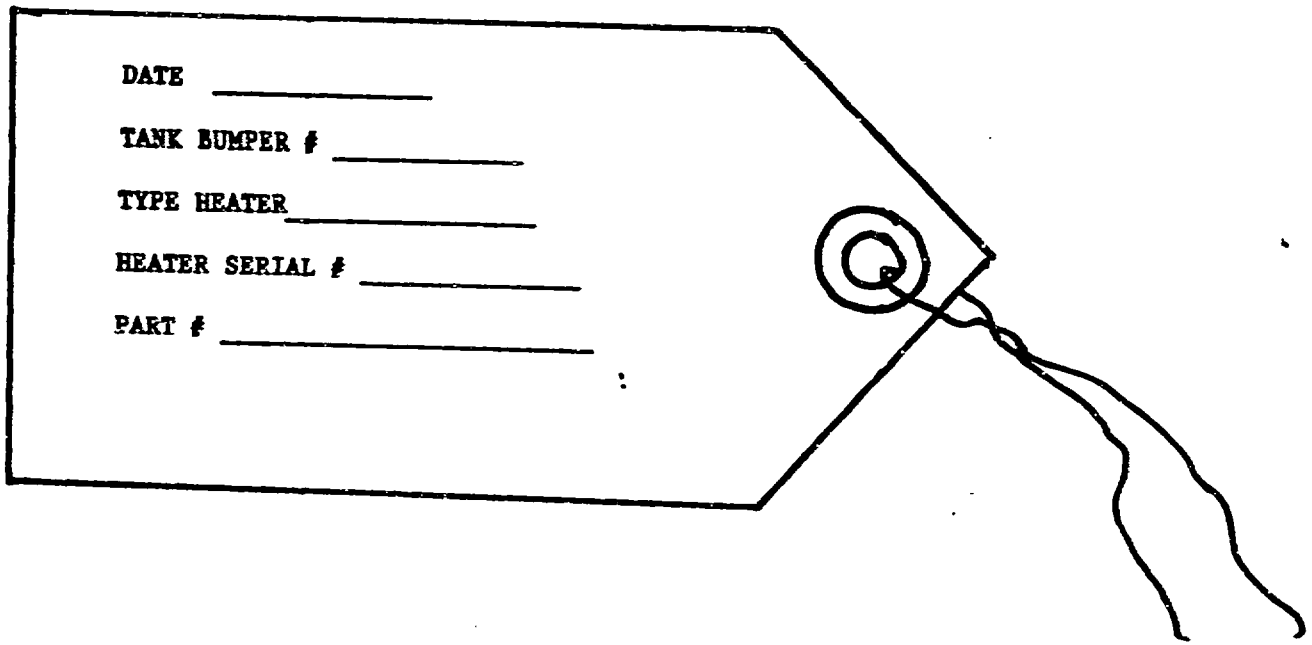
BLOWER MOTOR ☐	IGNITER RELAY (Hupp only) ☐	PRE-HEAT BURNER THERMOSTAT(Hupp only) ☐
BURNER/WICK (S/W only) ☐	IGNITION CONTROL (10560C/M only) ☐	RESISTOR ASSEMBLY (Hupp only) ☐
DIODE ASSEMBLY (10560C/M only) ☐	IGNITION VOLTAGE Regulator(10660A only) ☐	RESOVOIR ASSEMBLY (Hupp only) ☐
FLAME DETECTOR SWITCH ☐	MOTOR CONTROL (10660A only) ☐	VALVE RELAY (Hupp only) ☐
FUEL REGULATOR ☐	OVERHEAT SWITCH ☐	VOLTAGE LIMITER (10560C/M only) ☐
IGNITER ☐	OTHER_____	

4. REMARKS

NOTE: After you fill out this form, staple it to the driver's/org maint. form and hold it with bad parts for pickup by TACOM rep.

INCL 2

INCL 3



Memorandum of Understanding

between

Project Manager's Office, M60 Tanks,
Tank-Automotive Command

and

704th Maintenance Bn, 4 Inf. Div. (Mech)
and
4-40 Ar. Bn., 4Inf. Div. (Mech)
Ft Carson, Co.

SUBJECT: Conduct of Heater Test at
Fort Carson During Winter 83.

inclosure 2

1. There are 39 M60 Tanks in 4-40 Armor participating in a winter personnel heater test for the Program Manager M60 Tank (the Materiel Developer). Throughout the duration of the test (17 December 1982-23 March 1983), the following special procedures have been established for DX and repair of the test heater:

a. All heaters will be color-coded with spray paint per the 1 December 1982 test plan (Incl 1).

b. All spare heater assemblies (15 model C and 5 model A) and spare components will be stored at the DS Maintenance Shop (Sgt Paulson). The only exception is a small supply of ignitors to be stocked at Organizational Maintenance. If GS Maintenance repairs a test heater, they will obtain required parts from the DS Unit.

c. When a 4-40 AR unit wants to DX a non-operational test heater, they will bypass the DX point. Instead they will take the heater directly to the 704th Maint. Bn Fuel and Electronics Shop (F&E Shop).

d. The F&E Shop will either make a quick repair of the heater or issue the unit a replacement heater of the same color code.

e. The forms allocated by PM-M60 for this test, the "Driver's Record" and "Organization Maintenance Record" must accompany any defective heater transported to the F&E Shop. No test heaters will be accepted without the above forms.

f. All failed parts will be tagged with manila tags provided by PM-M60. They will be picked up on regular liaison visits by PM-M60 representatives (see Incl 1).

g. The maintenance concepts as promulgated in M60 series Tank Technical Manual regarding heaters have been suspended for this test for test heaters. Maintenance units will repair test heaters as they have been instructed by TACOM contractor personnel. Special "Test Only" Technical Manuals will be given to maintenance personnel to describe fully the maintenance concepts for the test, i.e., SMR codes, repair parts allocation, and allowable repairs.

h. F&E Shop personnel will complete the DA Form 2407 Maintenance Request at their location.

i. Units of 4-40 AR will turn in forms to the HHC Maintenance Office ATTN: Sgt Paradis/SFC Bridges.

2. The following personnel will serve as points of contacts during the test for the designated areas:

NAME	OFFICE	PHONE	AREA
MAJ G. F. Rogers	PM-M60, TACOM	A/V 786-6732	Heater Test Manager
Mr. C. Fleetham	DRTSTA-MCB, TACOM	A/V 786-7378	Heater Test Maintenance
CW4 Maddox	DMMC	Ext. 3580	Prime 4th Inf Div POC
MAJ Hunter	4-40 Ar, Exc Officer	Ext. 3986	Prime 4-40 AR POC for TACOM & PM-M60
CPT Korttrey	4-40 Ar BMO	Ext. 2919	BMO POC
SGT Paradis	4-40 Ar HHC	Ext. 2919	Organizational Maint POC
CPT Main	704th Maint. Bn, MATO		Prime DS POC

SGT Paulson	704th Maint. Bn, F&E Shop	Prime DS Maint POC

3. Above POC's will be contacted for problem resolution in their respective areas, beginning with the lowest, nearest echelon.

1 Incl
as

CF: DRSTA-MCB, TACOM
DMMC, Ft. Carson
ATTN: CW4 Maddox

W. Ashley III, GS-13
PMO-M60

MAJ. SPECK
704th Mt Bn

MAJ. Hunter
4-40 Ar

Sgt. Paulson
704th Mt. Bn

MAJ G. F. Rogers
PMO-M60

CW4 H. C. Maddox
DMMC

MAJ BURROUGHS
~~HHC~~ 3d Bde S4

APPENDIX B

TANK CREW EXIT SURVEY

AND

SURVEY RESULTS

TANK CREW MEMBER

FT. CARSON HEATER TEST
EXIT SURVEY

Instructions: Circle the correct answer or fill in the blank.

Your present tank bumper number: _____

Color of your test heater: Black/Blue/Red/Yellow

Your Job: Tank Commander/Gunner/Loader/Driver

1. How many years experience do you have as a tank crewman? _____

2. How long have you been assigned to this unit? _____

3. Have you been assigned to this same tank since 1 January 1983? Yes/No

4. What bumper number tank did you you go"down range" on in January? _____

5. What bumper number tank did you go to tank gunnery on in March? _____

6. During the test (1 January - 23 March 1983) I generally had not enough/adequate/too much heat from the heater.

7. The heater and heater support system on test in my tank performed worse/about the same/better than the "standard" tank heater I normally use.

8. When your heater fails to start, what do you do first?

   A. Replace the igniter

   B. Remove the heater assembly from the tank

   C. Adjust heater switches

   D. Contact organizational maintenance

   E. Other: _____

9. When you went "down range" did you

   A. Turn the heater on only when you got cold

   B. Leave the heater on all the time (even when you really weren't cold)

   C. Never used the heater

   D. Other (please explain)_____

10. The part on my heater which I had to replace or adjust most often during the test was the:_____

11. When my heater fails, the person who normally works on it is:

    A. Me

    B. Another member of the tank crew.

    C. An organizational mechanic

12. Did your heater overheat during the test?

    A. Never

    B. Once or twice

    C. Often

    D. Don't know

13. Did your heater flood with fuel when you tried to start it?

    A. Never

    B. Once or twice

    C. Often

    D. I don't know

14. Power pack removal/installation during the test was:

    A. Easier than normal

    B. No different than normal

    C. Harder than normal (please explain)

    _____

    _____

15. If the heater does not start right away, I normally

    A. Leave the start switch on until the heater starts.

    B. Turn the start switch off and troubleshoot

    C. Turn the start switch off and contact organizational maintenance

16. I can fix my heater as well as or better than organizational mechanics.

True

False

17. When your heater was working during the test, compare the heat distribution on your tank with what it was before the test.

Driver:	A. More comfortable B. Less comfortable C. About the same D. Don't know	Gunner:	A. More comfortable B. Less comfortable C. About the same D. Don't know
Loader:	A. More comfortable B. Less comfortable C. About the same D. Don't Know	TC:	A. More comfortable B. Less comfortable C. About the same D. Don't know

18. The portable fire extinguisher on my tank was set off by the heater during the test.

A. No

B. Yes, once

C. Yes, more than once

19. The Fixed fire extinguisher on my tank was set off by the heater during the test.

A. No

B. Yes, once

C. Yes, more than once

20. Only answer this question if you had a "RED or "BLUE" Tank.

a. How often did you drain the water from the bottom of the heater fuel filter?

A. Daily

B. Weekly

C. Seldom

D. Never

b. What did you use to catch the water in?

_____

Summary of Questionnaire Responses for BLUE (Model "A" with Engine Filter/Heat Tape) System

		Total Crew		TC's Only	
		#	%	#	%
1. Heat Output:	Not Enough	3	11%	1	11%
	Adequate	22	79%	8	89%
	Too Much	1	4%	-	-
	Unknown	2	7%	-	-
2. Heater Performance:	Worse	4	14%	1	11%
	Same	7	25%	2	22%
	Better	15	54%	6	67%
	Unknown	2	7%	-	-
3. First Action on Heater Failure:	Repl Igniter	2	7%	1	11%
	Remove Htr	2	7%	1	11%
	Adjust Sw's	1	4%	-	-
	Contact Maint	15	54%	4	44%
	Other	8	29%	3	33%
4. Heater Use:	Only when cold	18	64%	7	78%
	On all the time	4	14%	1	11%
	Never used it	2	7%	1	11%
	Other	4	14%	-	-
5. Part Replaced Most Frequently:	Igniter	3	11%	1	11%
	Flame Det SW.	1	4%	1	11%
	None/NA/UNK	23	82%	6	67%
	Other	1	4%	1	11%

Summary of Questionnaire Responses for BLUE (Model "A" with Engine Filter/Heat Tape) System

Summary of Questionnaire Responses for BLUE (Model "A" with Engine Filter/Heat Tape) System

		Total Crew #	Total Crew %	TC's Only #	TC's Only %
6. Who works on heater?	ME	8	30%	3	33%
	Another Crewman	7	26%	2	22%
	Org Mech	9	33%	3	33%
	Not Required	3	11%	1	11%
7. Did Heater Overheat?	Often	21	78%	8	89%
	Unknown	1	4%	1	11%
8. Did Heater Flood?	Often	22	76%	6	67%
	Unknown	2	7%	1	11%
9. Power Pack Removal:	Easier	-	-	-	-
	Same	23	92%	9	100%
	Harder	2	8%	-	-
	Unknown	24	92%	9	100%
10. If Heater Doesn't Start:	Harder	2	8%	-	-
	Leave it on	6	19%	1	10%
	Turn off, troubleshoot	16	52%	5	50%
	Turn off, get org. mech.	8	26%	4	40%
	Unknown	15	53%	4	40%
11. I can fix Htr Better than org mech:	Turn off, get org. mech.	8	26%	1	40%
	True	13	46%	6	67%
	False	15	54%	3	33%

Summary of Questionnaire Responses for BLUE (Model "A" with Engine Filter/Heat Tape) System

		Driver		Loader		Gunner		TC's	
		#	%	#	%	#	%	#	%
12. Heat Distribution	Better	4	40%	5	63%	5	45%	7	78%
	Worse	-	-	1	13%	2	18%	1	11%
	Same	6	60%	2	25%	4	36%	1	11%
	Unknown	-	-	-	-	-	-	-	-

13. Fire Extinguisher Blew Off:

Portable: Responses were contradictory among the same crews:
Definite: A15, A66, A35, A65
Probable: A31
Possible: A11, A24

Fixed — Definite: A31, A35

		Crew		Driver		TC's	
		#	%	#	%	#	%
14. Engine Fuel Filter SVC:	Daily	4	15%	1	17%	1	13%
	WKLY	9	35%	2	33%	4	50%
	Seldom	-	-	-	-	-	-
	Never	13	50%	3	50%	3	38%
Caught Fuel in:	"C"rat Can	1	8%	-	-	1	25%
	Can	10	83%	3	100%	3	75%
	Floor	1	8%	-	-	-	-

Summary of Questionnaire Responses for R3D (Engine Filter/Heat Tape) System

		Total Crew		TC's Only	
		#	%	#	%
1. Heat Output:	Not Enough	8	42%	3	60%
	Adequate	9	47%	2	40%
	Too Much	-	-	-	-
	Unknown	2	11%	-	-
2. Heater Performance:	Worse	8	42%	3	60%
	Same	9	47%	2	40%
	Better	1	5%	-	-
	Unknown	1	5%	-	-
3. First Action on Heater Failure:	Repl. Igniter	3	16%	-	-
	Remove Htr	-	-	-	-
	Adjust Sw's	-	-	-	-
	Contact Maint	13	68%	4	80%
	Other	3	16%	1	20%
4. Heater Use:	Only when cold	8	42%	3	75%
	On all the time	5	26%	1	25%
	Never used it	4	21%	-	-
	Other	2	11%	-	-
5. Part Replaced Most Frequently:	Igniter	8	42%	3	50%
	Flame Det. SW.	3	16%	-	-
	None/NA/UNK	8	42%	3	50%
	Other	-	-	-	-

Summary of Questionnaire Responses for RED (Engine Filter/Heat Tape) System

		Total Crew		TC's Only	
		#	%	#	%
6. Who works on heater?	ME	3	16%	1	20%
	Another crewman	7	37%	-	-
	Org Mech	9	47%	4	80%
7. Did Heater Overheat?	Never	10	53%	5	100%
	Once or Twice	3	16%	-	-
	Often	-	-	-	-
	Unknown	6	32%	-	-
8. Did Heater flood?	Never	6	32%	3	60%
	Once or Twice	5	26%	1	20%
	Often	3	16%	1	20%
	Unknown	5	26%	-	-
9. Power Pack Removal:	Easier	-	-	-	-
	Same	12	63%	2	40%
	Harder	-	-	-	-
	Unknown	7	37%	3	60%
10. If Heater Doesn't start:	Leave it on	4	21%	1	20%
	Turn off, troubleshoot	5	26%	1	20%
	Turn off, get org mech	10	53%	3	60%
11. I can fix Htr Better than org mech:	True	9	47%	5	100%
	False	10	53%	-	-

Summary of Questionnaire Responses for RED (Engine Filter/Heat Tape) System

		Driver		Loader		Gunner		TC's	
		#	%	#	%	#	%	#	%
12. Heat Distribution:	Better	-	-	-	-	3	38%	1	20%
	Worse	2	18%	1	33%	-	-	-	-
	Same	7	64%	2	67%	3	38%	3	60%
	Unknown	2	18%	-	-	2	25%	1	20%

13. Fire Extinguisher Portable: Definite: B25, B32, B52

Blew Off: Fixed: Definite: B25

		Crew		Driver		TC's	
		#	%	#	%	#	%
14. Engine Fuel Filter SVC:	Daily	2	11%	1	13%	1	20%
	WKLY	3	16%	1	13%	1	20%
	Seldom	1	5%	1	13%	-	-
	Never	13	68%	5	63%	3	60%
Caught Fuel in:	"C"rat Can	1	17%	-	-	1	50%
	Can	2	33%	2	67%	-	-
	Floor	3	50%	1	33%	1	50%

Summary of Questionnaire Responses for YELLOW (DAVCO) System

		Total Crew		TC's Only	
		#	%	#	%
1. Heat Output:	Not Enough	10	42%	2	25%
	Adequate	11	46%	4	50%
	Too Much	3	13%	2	25%
	Unknown	-	-	-	-
2. Heater Performance:	Worse	11	46%	3	50%
	Same	9	38%	3	50%
	Better	3	13%	-	-
	Unknown	1	4%	-	-
3. First Action on Heater Failure:	Repl. Igniter	5	22%	2	29%
	Remove Htr	1	4%	-	-
	Adjust Sw's	-	-	-	-
	Contact Maint	8	35%	2	29%
	Other	9	39%	3	43%
4. Heater Use:	Only when cold	16	47%	4	57%
	On all the time	11	32%	1	14%
	Never used it	3	9%	-	-
	Other	4	12%	2	29%
5. Part Replaced Most Frequently:	Igniter	5	22%	1	14%
	Flame Det. SW.	3	13%	1	14%
	None/NA/UNK	14	61%	4	57%
	Micro SW	1	4%	1	14%

Summary of Questionnaire Responses for YELLOW (DAVCO) System

		Total Crew		TC's Only	
		#	%	#	%
6. Who works on heater?	ME	8	33%	3	43%
	Another crewman	9	38%	2	29%
	Org Mech	6	25%	1	14%
	Unknown	1	4%	1	14%
7. Did Heater Overheat?	Never	16	67%	5	71%
	Once or Twice	1	4%	1	14%
	Often	-	-	-	-
	Unknown	7	29%	1	14%
8. Did Heater flood?	Never	9	38%	3	43%
	Once or Twice	7	29%	2	29%
	Often	6	25%	1	14%
	Unknown	2	8%	1	14%
9. Power Pack Removal:	Easier	1	4%	1	14%
	Same	16	67%	3	43%
	Harder	4	17%	3	43%
	Unknown	3	13%	-	-
10. If Heater Doesn't start:	Leave it on	4	17%	-	-
	Turn off, troubleshoot	14	58%	5	71%
	Turn off, get org mech.	4	17%	1	14%
	Unknown	2	8%	1	14%
11. I can fix Htr Better than org mech:	True	11	46%	5	71%
	False	13	54%	2	29%

Summary of Questionnaire Responses
for YELLOW (DAVCO) System

		Driver		Loader		Gunner		TC's	
		#	%	#	%	#	%	#	%
12. Heat Distribution:	Better	4	31%	2	25%	5	56%	2	40%
	Worse	3	23%	3	38%	2	22%	-	-
	Same	5	38%	1	13%	-	-	2	40%
	Unknown	1	8	2	25%	2	22%	3	60%

13. Fire Extinguisher Blew Off:	Portable:	Definite:	C35
		Probable:	C33, C34
	Fixed	Definite:	A34 (twice), B21

Summary of Questionnaire Responses for BLACK (Standard) System

		Total Crew		TC's Only	
		#	%	#	%
1. Heat Output:	Not Enough	11	46%	4	67%
	Adequate	13	54%	2	33%
	Too Much	-	-	-	-
	Unknown	-	-	-	-
2. Heater Performance:	Worse	10	42%	2	33%
	Same	12	50%	3	50%
	Better	1	4%	1	17%
	Unknown	1	4%	-	-
3. First Action on Heater Failure:	Repl. Igniter	3	13%	1	17%
	Remove Htr	1	4%	1	17%
	Adjust Sw's	1	4%	-	-
	Contact Maint	15	65%	3	50%
	Other	3	13%	1	17%
4. Heater Use:	Only when cold	11	46%	1	17%
	On all the time	7	29%	3	50%
	Never used it	1	4%	1	17%
	Other	5	21%	1	17%
5. Part Replaced Most Frequently:	Igniter	9	38%	3	50%
	Flame Det SW	-	-	-	-
	None/NA/UNK	13	54%	3	50%
	Other	2	8%	-	-

Summary of Questionnaire Responses for BLACK (Standard) System

			Total Crew		TC's Only	
			#	%	#	%
		ME	7	29%	5	83%
6.	Who works on heater?	Another crewman	7	29%	-	-
		Org Mech	10	42%	1	17%
		Never	20	80%	6	100%
7.	Did Heater Overheat?	Once or Twice	1	4%	-	-
		Often	-	-	-	-
		Unknown	4	16%	-	-
		Never	13	54%	3	50%
		Once or Twice	7	29%	2	33%
8.	Did Heater flood?	Often	1	4%	-	-
		Unknown	3	13%	1	17%
		Easier	2	8%	-	-
9.	Power Pack Removal:	Same	18	75%	5	83%
		Harder	2	8%	1	17%
		Unknown	2	8%	-	-
		Leave it on	12	50%	3	50%
10.	If Heater Doesn't start:	Turn off, troubleshoot	5	21%	2	33%
		Turn off, get org mech	7	29%	1	17%
11.	I can fix Htr	True	10	43%	4	67%
	Better than org mech:	False	13	57%	2	33%

Summary of Questionnaire Responses for BLACK (Standard) System

		Driver		Loader		Gunner		TC's	
		#	%	#	%	#	%	#	%
12. Heat Distribution	Better	-	-	-	-	1	10%	1	17%
	Worse	2	20%	1	20%	1	10%	1	17%
	Same	8	80%	4	80%	7	70%	3	50%
	Unknown	-	-	-	-	1	10%	1	17%

13. Fire Extinguisher Blew Off:	Portable:	Definite:	C24
		Possible:	C22
	Fixed	None	

APPENDIX C

ORGANIZATIONAL MECHANIC
EXIT SURVEY
AND
SURVEY RESULTS

Mechanic

FT. CARSON HEATER TEST

EXIT SURVEY

Instructions: Circle the correct answer or fill in the blank.

Your present Company: A/ B/ C/ HHC/ CSC/

Your Job Title: _____

1. How many years experience do you have working on tanks? _____

2. How long have you been assigned to this Company? _____

3. During the test (1 January - 23 March 1983) I generally had more/about the same/ less heater complaints from the tank crews to investigate.

4. When you were called on to work on a heater inside a tank during the test what did you do first?

   A. Replace the igniter.

   B. Remove the heater assembly from the tank.

   C. Adjust heater switches.

   D. Follow the troubleshooting steps in the test manuals.

   E. Other:_____
   _____

5. The part on the heaters which I had to replace or adjust must often during the test was the:_____

6. In my unit, tank crew members repair their own heaters without my help.

   A. Occasionally.

   B. Most of the time.

   C. Never.

7. Power pack removal (installation during the test was:

   A. Easier than normal.

   B. No different than normal.

   C. Harder than normal (please explain):
   _____
   _____
   _____

8. Do you use commercial heater technical manuals (printed by companies such as Stewart Warner or Hupp) instead of Army manuals?

   A. Occasionally.

   B. Most of the time.

   C. Never.

   D. Don't know.

9. Were the test manuals (with RED/BLUE/YELLOW or BLACK covers) adequate to troubleshoot and/or repair the heaters?

   YES/ NO/ DON'T KNOW

10. Were the test manuals (with RED/BLUE/YELLOW or BLACK covers) adequate to troubleshoot and/or repair the heater support system (fuel lines, fuel pumps, fuel filters, etc).

    YES/ NO/ DON'T KNOW

    Comments:

    _____
    _____
    _____

11. Did any of the test hardware create a safety hazard for you or the crew?

    YES/ NO/ DON'T KNOW

    Explain:

    _____
    _____
    _____

12. Which one of the heater support systems was easier to repair?

    A. Red

    B. Blue

    C. Black

    D. Yellow

    E. No difference

    F. Don't know

Which one was the hardest to repair?

A. Red

B. Blue

C. Black

D. Yellow

E. No difference

F. Don't know

Why?_____

_____

_____

13. Was the supply of heater repair parts furnished <u>for this test</u> enough to keep your heaters running?

YES/ NO/ DON'T KNOW

14. Should mechanics at your level be allowed to do more work on the heaters and replace more parts?

NO

YES - Which parts? _____

_____

15. Should crew members be allowed to work on their own heaters?

YES/ NO/

16. Have you ever received any formal <u>Army</u> training on how to troubleshoot/repair heaters?

NO

YES - Where? _____

_____

Summary of Responses for Organizational Mechanics

		#	%	NOTES
1. Heater Complaints:	More	3	38%	
	Same	4	50%	
	Less	-	-	
	Unknown	1	13%	
2. First Action on Failure:	Repl Igniter	1	13%	
	Remove Htr	1	11%	
	Adj Mtr SW	-	-	
	Follow Troubleshooting in manual	6	67%	
	Check out Htr w/o manual	1	11%	
3. Parts replaced or Adj. Most Often:	Igniter	6	67%	
	Fuel Pump	1	11%	
	Flooding	1	11%	
	Not allowed to work	1	11%	
4. Crew Members Repair Htrs:	Occasionally	2	22%	
	Most of the time	4	44%	
	Never	3	33%	
5. Pack Removal:	Easier	2	22%	
	Same	1	11%	
	Harder	6	67%	(All mentioned DAVCO)

Summary of Responses for Organizational Mechanics

			#	%	NOTES
6.	Do you Use Commerical Manuals?	Occassionally	1	13%	
		Most of Time	6	75%	
		Never	1	13%	
7.	Were Test Manuals adequate to trouble-shoot Heaters?	Yes	7	78%	
		No	1	11%	However, he never used them.
		Don't Know	1	11%	
8.	Were test manuals adequate to trouble-shoot Spt systems?	Yes	5	56%	
		No	2	22%	(Lots of problems w/fuel & electric system)
9.	Were there safety problems?	No	7	78%	
		Don't Know	1	11%	
		Yes	1	11%	(If tank catches on fire rubber heater hose can fuel the fire. Also, some fire ext's went off due to High heat.)
10.	Which Spt Sys was easiest to repair?	Red	-	-	
		Blue	2	22%	
		Black	1	11%	(He only worked on black)
		Yellow	1	11%	
		No Diff	4	44%	
		Unknown	1	11%	

Summary of Responses for Organizational Mechanics

		#	%	
11. Which Spt Sys was hardest to repair?	Red	-	-	
	Blue	-	-	
	Black	-	-	
	Yellow	2	22%	(Problems with DAVCO)
	No Diff	4	44%	
	Unknown	3	33%	
12. Was supply of heater parts adequate?	Yes	3	38%	
	No	3	38%	
	Unknown	2	25%	
13. Should Org Mech's be allowed to do more work?	No	3	27%	
	Yes	6	55%	(All parts - 4 responses)
	Igniter	1	9%	
	Fl Det	1	9%	
14. Should crew members be allowed to work on their Htrs?	Yes	5	56%	
	No	4	44%	
15. Have you received formal Army Tng on Htr Repair?	No	7	78%	
	Yes	2	22%	

APPENDIX D

TEMPERATURE DATA

FT. CARSON WINTER PERSONNEL HEATER TEST

WEATHER DATA

Air Force 2LT Kanikula
AUTOVON 691-3620
Ft. Carson Army Airfield

DATE	HIGH TEMPERATURE °F	LOW TEMPERATURE °F
17 Dec 1982	72	40
18 Dec 1982	53	40
19 Dec 1982	Ft. Carson Airfield Closed-Sunday	
20 Dec 1982	52	34
21 Dec 1982	61	44
22 Dec 1982	62	40
23 Dec 1982	49	32
24-26 Dec 1982	Closed - Holidays	
27 Dec 1982	39	33
28 Dec 1982	20	14
29 Dec 1982	25	7
30 Dec 1982	27	15
31 Dec - 2 Jan 83	Closed - Holidays	
3 Jan 1983	52	28
4 Jan 1983	40	27
5 Jan 1983	54	34
6 Jan 1983	60	31
7 Jan 1983	53	36
8 Jan 1983	57	30
9 Jan 1983	Closed - Sunday	
10 Jan 1983	50	18
11 Jan 1983	53	33
12 Jan 1983	60	33
13 Jan 1983	66	29
14 Jan 1983	42	28
15 Jan 1983	52	22
16 Jan 1983	Closed - Sunday	

FT CARSON WINTER PERSONNEL HEATER TEST
WEATHER DATA

Air Force 2LT Kanijula
AUTOVON 691-3620
Ft Carson Army Airfield

DATE	HIGH TEMPERATURE °F	LOW TEMPERATURE °F
17 Jan 83	39	24
18 Jan 83	31	24
19 Jan 83	42	25
20 Jan 83	29	22
21 Jan 83	23	19
22 Jan 83	41	20
23 Jan 83	Closed Sunday	
24 Jan 83	40	26
25 Jan 83	40	31
26 Jan 83	39	22
27 Jan 83	45	30
28 Jan 83	52	32
29 Jan 83	40	26
30 Jan 83	Closed Sunday	
31 Jan 83	31	25
1 Feb 83	30	24
2 Feb 83	31	20
3 Feb 83	24	20
4 Feb 83	25	19
5 Feb 83	34	23
6 Feb 83	Closed Sunday	
7 Feb 83	48	22
8 Feb 83	38	27
9 Feb 83	50	29
10 Feb 83	49	35
11 Feb 83	43	25
12 Feb 83	50	26
13 Feb 83	Closed Sunday	
14 Feb 83	44	36
15 Feb 83	45	27
16 Feb 83	54	32
17 Feb 83	49	27
18 Feb 83	56	33

FT CARSON WINTER PERSONNEL HEATER TEST
WEATHER DATA

Air Force 2LT Kanijula
AUTOVON 691-3620
Ft Carson Army Airfield

DATE	HIGH TEMPERATURE °F	LOW TEMPERATURE °F
19-21 Feb 83	Closed - Holidays	
22 Feb 83	51	36
23 Feb 83	57	33
24 Feb 83	40	30
25 Feb 83	60	29
26 Feb 83	58	35
27 Feb 83	Closed - Sunday	
28 Feb 83	59	31
1 Mar 83	63	33
2 Mar 83	66	38
3 Mar 83	61	40
4 Mar 83	44	37
5 Mar 83	39	37
6 Mar 83	Closed - Sunday	
7 Mar 83	53	29
8 Mar 83	48	32
9 Mar 83	51	26
10 Mar 83	60	31
11 Mar 83	68	34
12 Mar 83	63	44
13 Mar 83	Closed - Sunday	
14 Mar 83	56	39
15 Mar 83	34	31
16 Mar 83	36	30
17 Mar 83	28	24
18 Mar 83	26	23
19 Mar 83	25	20
20 Mar 83	Closed - Sunday	
21 Mar 83	36	13
22 Mar 83	28	26
23 Mar 83	32	24

APPENDIX E

EXTRACTS FROM PROPOSED REVISION TO MILITARY SPECIFICATION MIL-H-62315A(AT)

24 January 1983

PROPOSED REVISION TO MILITARY SPECIFICATION
MIL-H-62315A(AT)

HEATER ASSEMBLY, COMBUSTION,
VEHICULAR COMPARTMENT, 60,000 BTU/HR

1. SCOPE

1.1 Scope. This specification establishes the performance, design, testing, manufacturing, and acceptance requirements for a forced air inlet personnel heater assembly.

1.2 Item definition. The personnel heater, referred to herein as "heater", shall be a diesel fuel burning unit with an electrical control system and an electric blower.

2. APPLICABLE DOCUMENTS

2.1 Issues of documents. The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

FEDERAL

GG-P-455	Plates and Foils, Photographic (Photosensitive Anodized Aluminum.)
QQ-P-416	Plating, Cadmium (Electrodeposited).
TT-E-485	Enamel, Semigloss, Rust-inhibiting.
TT-E-529	Enamel, Alkyd, Semigloss.
TT-P-636	Primer Coating, Alkyd, Wood and Ferrous Metal.
VV-F-800	Fuel Oil, Diesel.

MILITARY

MIL-P-514	Plates, Identification, Instruction and Marking, Blank.
MIL-C-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys.
MIL-P-14105	Paint, Heat-resisting, (for Steel Surfaces).
MIL-P-19834	Plate, Identification, Metal Foil, Adhesive Backed.

STANDARDS

FEDERAL

FED-STD-595	Colors.

MILITARY

MIL-STD-100	Engineering Drawing Practices
MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes.
MIL-STD-130	Identification Marking of U.S. Military Property.
MIL-STD-454	Standard General Requirements for Electronic Equipment.
MIL-STD-461	Electromagnetic Interference Characteristics, Requirements for Equipment.
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of.
MIL-STD-810B	Environmental Test Methods.
MIL-STD-889	Dissimilar Metals.
MIL-STD-45662	Calibration System Requirements.

(Copies of specifications, standards, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity, or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

19.5.4	Power Test Code.

(Application for copies should be addressed to the American Society of Mechanical Engineers, 345 E. 47th Street, New York, New York 10017.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D-2156	Smoke Density in Flue Gases from Burning Distillate Fuels, Test for.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.)

AIR MOVING CONDITIONING ASSOCIATION (AMCA)

210-74	Test Code for Air Moving Devices.

(Application for copies should be addressed to the Air Movement and Control Association, 320 W. University Drive, Arlington Heights, Il 60004.)

3. REQUIREMENTS

3.1 First article (preproduction). The contractor shall furnish sample units for first article inspection and approval (see 4.4 and 6.3). First article samples shall be inspected by the contractor under the surveillance of the Government to determine conformance to the quality assurance provisions of this specification. First article samples shall be fully representative of heater to be supplied from production tooling and facilities.

3.2 First production heater. The first production heater(s) shall be fully representative of heaters proposed to be furnished under the contract with all current modifications included. Heater(s) shall be examined and tested to determine conformance to all requirements of this specification. If submitted heater(s) meets all requirements of this specification, no modifications shall be applied to subsequent heaters to be produced under the contract without prior approval by the Government.

3.3 Materials. Materials shall be as specified herein, in applicable specifications, or drawings. Materials not specifically designated shall be suitable for use in heaters operating over specified ranges, without any change in properties that would result in operation of the units falling outside of the specified limits (see 6.5). The heater shall be fabricated from suitable corrosion-resistant materials or treated to prevent corrosion.

3.3.1 Dissimilar metals. Except where necessary to complete an electrical circuit, the compatibility of dissimilar metals shall be in accordance with MIL-STD-889.

3.4 Design and construction. Heaters shall be constructed to the form and dimensions depicted on drawing number TBD.

3.4.1 Protective coating. All steel parts, except stainless steel, that are subjected to temperatures exceeding 200°F, shall be painted with two coats of high temperature olive drab enamel conforming to MIL-P-14105. Surfaces shall be free of oil, grease, rust and mill scale before applying enamel finish. All other painted steel parts shall be finished in accordance with MIL-P-14105, or primed with primer conforming to TT-P-636, and finished with enamel conforming to TT-E-529 or TT-E-485, color to match 24087 of FED-STD-595.

3.4.2 Steel components. Unpainted steel components, other than stainless steel, shall be cadmium plated in accordance with QQ-P-416, type II, class 2. Radiation surfaces may be aluminized steel.

3.4.3 Aluminum components. Aluminum components shall be anodized in accordance with MIL-C-5541, class 1A.

3.4.4 Marking and identification.

3.4.4.1 Marking. Unless otherwise specified (see 6.2), heater shall be marked in accordance with MIL-STD-130.

3.4.4.2 Identification. As specified (see 6.2), nameplates shall be furnished in one of the following configurations:

a. Material and construction shall conform to MIL-P-514, type III, composition A, class 2, or composition C. Composition C material shall conform to GG-P-455, type II, grade A, class 1. Nameplate shall be permanently attached with metal fasteners.

b. Adhesive backed aluminum foil shall conform to MIL-P-19834, type I, glossy: except backing sheet, which may be of paper, shall be removable intact by stripping without use of water or other solvents. Plate shall have an average adhesion, over bare and painted metal surfaces, of not less than 50 ounces per inch, of width at $77^{\circ} \pm 5^{\circ}F$.

3.4.5 Workmanship. Heater shall be free of defects such as burrs, scratches, chips, sharp edges, corrosion, scale and dirt. Workmanship shall also be in accordance with requirement 9 of MIL-STD-454.

3.4.6 Safety. Hot spots that could create a hazard to personnel shall be minimized and shall be identified on the drawings by the contractor. The heater shall be so designed that, with proper installation, heater exhaust gases cannot enter the vehicle personnel compartment.

3.4.7 Weight. Weight of the heater shall not exceed 38 pounds.

3.4.8 Operating position. The heater shall meet the performance requirements specified herein when mounted in any position from horizontal to vertical with the air inlet level with, or higher than, the air outlet.

3.4.9 Interchangeability. The assembly shall be so designed and fabricated that all component assemblies and parts are functionally and dimensionally interchangeable with like component assemblies and parts previously furnished by the same manufacturer. Construction shall be such that any part, except those furnished in matched sets or for which a selective fit is specified, may be installed, replaced, and adjusted without requiring modification.

3.5 Performance.

3.5.1 Heater voltage. The heater shall start and meet performance requirements specified here in "low" and in "high" heat modes, with an applied voltage of 19 to 30 volts direct current (VDC), 24 VDC nominal.

3.5.2 Current. At a 24 VDC, the maximum current drawn from the power source shall be as follows:

Ambient above $45^{\circ}F$	Starting 16.0 Amps Running 15.0 Amps
Ambient below $45^{\circ}F$	Starting 23.0 Amps Running 20.0 Amps

3.5.3 Fuel. The heater shall perform as specified herein using fuel conforming to VV-F-800 as follows:

Above plus (+) 20°F	Type DF-2
Plus (+) 20°F to minus (-) 25°F	Type DF-1
Below minus (-) 25°F	Type DF-A

3.5.4 Fuel consumption. With any fuel pressure between 3 and 15 pounds per square inch gage (psig) at the fuel inlet valve. Fuel consumption will be as follows:

High heat setting	0.092 pounds per minute (lbs/min) maximum
Low heat setting	0.052 lbs/min maximum

3.5.5 Heat output. With a ventilating back pressure of 1.30 inches of water and an exhaust back pressure of 0.85 inch of water, heater output shall be as follows:

High heat	19.0 to 30.0 vdc, 54,000 British thermal units per hour (Btu/hr) minimum
Low heat	19.0 to 30.0 vdc, 30,000 Btu/hr ±20%

The air flow restrictions specified are to be set at 24 vdc input only and maintained in this position at all voltages.

3.5.6 Air discharge rate. At "low" and "high" heat settings and with 24 vdc applied to the heater, the ventilating air discharge rate, based on standard air density of 0.075 lb/ft^3 at standard barometer (29.92 in. of Hq.) and 70°F, shall be as follows:

At 1.30 in. water ventilation Back pressure (nominal)	150 SCFM min.
And 0.85 in. water exhaust Back pressure (nominal)	and 190 SCFM nominal

NOTE: With the heater operating on high heat, the ventilating air discharge rate, based on standard air density of 0.075 pounds per cubic foot at 29.92 inches of mercury 70°F, restrictions shall be fixed to produce the above values.

3.5.7 Overheat control. The overheat control shall shut off fuel flow and induce heater purge when the ventilating air temperature reaches 400° ± 75°F. The heater, after completing the purge cycle, shall shut down.

3.5.8 Temperature limit control. The heater shall be equipped with a temperature control that shall be capable of limiting the ventilating air outlet temperature to a range of 280 ± 20°F.

3.5.9 Flame detector control. The flame detector control shall sense burner flame temperatures during start, run and purge cycles. The control shall control start or abort cycles. The control, during the abort cycle, shall induce purge cycling prior to heater shut down. The period from start to run shall not exceed four minutes. The duration of purge shall be 3.5 minutes maximum. The flame detector control shall automatically override the manual control in the event of start failure and shut down the heater within the 4 minute start/run cycle.

3.5.10 Smoke density. After the heater has been operating for five minutes, minimum, exhaust gases shall not exceed a smoke spot number of three except that at an ambient temperature of 73° ± 18°F, and a voltage of 19 ± 0.5 vdc, the smoke spot number shall not exceed five. Smoke spot numbers are defined in ASTM D-2156-65.

3.5.11 Starting time. The starting time, measured from the time the heater is turned on until the igniter circuit is deenergized, shall not be greater than 4.0 minutes.

3.5.12 Purging time. The purging time, measured from the time the heater switch is turned off until the blowers shut off, shall not be greater than 3.5 minutes.

3.5.13 Fuel leakage. There shall be no visible leakage from the heater fuel components during a period of 5 minutes, minimum, with the heater operating and 14 ± 1 psig fuel pressure applied to the inlet.

3.5.14 Toxic fumes. Combustion and ventilating air in the heater shall be isolated from each other, after combustion. In operation, the heater shall not contaminate the ventilating air with products of combustion.

3.5.15 Endurance. The heater shall be capable of meeting the requirements of 3.5 after 800 hours of operation including 2400 minimum start cycles using DF-1, DF-2, and DF-A fuel. The only maintenance permitted is cleaning of fuel screens and filters as required.

3.5.16 Electromagnetic radiation. During any mode of operation, or while changing modes of operation, the heater shall meet the requirements of MIL-STD-461, Notice 4, as modified by figures 1 through 4. Emissions having duration not exceeding one second and recurring not more than once in three minutes, are exempt. Applicability of MIL-STD-461 and figures 1 through 4 shall be as follows:

Requirement (MIL-STD-461)	Limits (MIL-STD-461)	Limits (This specification)
CE01		Figure 1
CE04 (+28 Vdc line)		Figure 2
RE02		Figures 3 and 4

3.6 Reliability. The minimum acceptable mean time-between-failure (MTBF) of the heater shall be 600 hours.

3.7 Environmental conditions. The heater shall meet the requirements of 3.5.1 through 3.5.14 after being subjected to each environmental condition specified in 3.7.1 through 3.7.6.

3.7.1 Operating temperature. The heater shall start and operate as specified herein at temperatures from plus 75°F to minus 55°F, provided that fuel is supplied in liquid form.

3.7.2 Storage temperature. The heater shall start and operate as specified herein before and after exposure to storage conditions ranging from minus 65°F to plus 160°F.

3.7.3 Humidity. The heater shall start and operate as specified herein during and after exposure to relative humidity up to 100 percent.

3.7.4 Corrosion. The heater shall start and operate as specified herein after exposure to 5 percent solution of sodium chloride salt fog for 96 hours.

3.7.5 Shock. The heater shall start and operate as specified herein after being subjected to half sine wave shock pulses 40 ± 4 g peak shock loading for a duration of 18 ± 3 milliseconds (MSEC) applied in both directions along three mutually perpendicular axes.

3.7.6 Vibration. The heater shall start and operate as specified herein during and after sinusoidal vibration in accordance with figure 5, for a period of 80 minutes minimum (including up to four resonance dwelling of 13-1/3 minutes each) in each of three mutually perpendicular axes.

3.8 Configuration control. Assemblies furnished under this purchase description shall have been tested and have passed the first article test specified in section 4. Configuration of the qualified asssembly shall be maintained by the supplier and made available to the procuring activity for review. Subsequent to qualification approval, changes in processes, materials, construction, design, etc. shall not be made without procuring activity approval.

APPENDIX F

EQUIPMENT PERFORMANCE REPORTS (EPRs) AND CLOSE-OUT CONFERENCE MINUTES

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C25
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C001	12-13-82	30,928

INCIDENT DESCRIPTION:
Heater failed to start during initial installation by contractor personnel. The igniter was reseated at DS maintenance and the heater was operational.

S-W FAILURE ANALYSIS:
No parts were replaced.

CHARGEABILITY:
Not chargeable - heater.

CLOSEOUT CONSIDERATIONS:
DS maintenance error. Failure to properly seat igniter during previous heater repair on 12-10-82 (see EPR C005).

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C15
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C002	12-13-82	30,923

INCIDENT DESCRIPTION:
Heater failed to start during initial installation by GDLS personnel. The heater was replaced.

S-W FAILURE ANALYSIS:
The igniter was found to be shorted.

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Date insufficient to understand problem.

Stewart Warner suspects the air was not removed from the fuel lines during initial installation.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C31
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C003	12-10-82	30,920

INCIDENT DESCRIPTION:
During initial instaliation by contractor personnel, the heater started as soon as electrical connection was made. The heater was purged of fuel and the flame detector switch and fuel flow were adjusted at DS maintenance.

S-W FAILURE ANALYSIS:
No parts were replaced.

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Flame detector switch out of adjustment.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: 834
MODEL: C
SUPPORT SYSTEM: DAVCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N	
C064	12-10-82	30,921	INCIDENT DESCRIPTION: Heater was discovered to be inoperative during initial installation by contractor personnel. The heater was replaced. S-W FAILURE ANALYSIS: The igniter was operational at Stewart Warner. CHARGEABILITY: Secondary heater failure - see C009. CLOSEOUT CONSIDERATIONS: Secondary failure attributed to long start attempts without fuel available at the heater (see C009).

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C25
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N	
C005	12-10-82	30,928	

INCIDENT DESCRIPTION:
Heater was found to be inoperative during initial installation by contractor personnel. The heater was purged of fuel and the flame detect switch was adjusted at DS maintenance.

S-W FAILURE ANALYSIS:
No parts were replaced.

CHARGEABILITY:
Not chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Maintenance Error

GDLS mechanics must have ommitted a step during initial installation such as purging the air from the fuel lines. Nothing wrong with the heater.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: A31
MODEL: A
SUPPORT SYSTEM: ENGINE FILTER
COLOR: BLUE

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C[illegible]6	12-13-82	104

INCIDENT DESCRIPTION:
During initial installation by GDLS, fan came on when power connection was made. A broken resistor was found on the circuit board. The resistor was replaced by Stewart Warner personnel at DS maintenance. A second model "A" heater was installed in the vehicle by GDLS and it also failed to operate. Stewart Warner personnel located a plugged heater exhaust pipe on the vehicle. Water and diesel fuel were blown out of the exhaust pipe and the second heater operated.

S-W FAILURE ANALYSIS:
Circuit board worked after resistor replacement.

CHARGEABILITY:
Not chargeable - support system.

CLOSEOUT CONSIDERATIONS:
Plugged heater exhaust pipe caused by crew error during vehicle washing. Broken resistor was damaged during Army transportation of the heater from the unit motor pool to the DS maintenance facility.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B64
MODEL: C
SUPPORT SYSTEM: ENGINE FILTER
COLOR: RED

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C067	1-7-83	30,907

INCIDENT DESCRIPTION:
The heater would not operate as a result of being flooded. The fuel quick-disconnect was disconnected and the heater was allowed to run. Problem resolved. (GDLS repaired).

S-W FAILURE ANALYSIS:
N/A

CHARGEABILITY:
Not chargeable - support system.

CLOSEOUT CONSIDERATIONS:
Suspect low vehicle battery voltage.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C31
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C008	1-6-83	30,910

INCIDENT DESCRIPTION:
Heater would not start. The electrical wiring inside the heater was burned. During removal the heater fuel pump bracket was found to b broken. The fuel pump was replaced and th heater was turned in for repair. DS found th blower motor to be burned out. The motor wa replaced and the heater was operational.

S-W FAILURE ANALYSIS:
Electrical wiring in blower housing burned du to a reverse burn (fire reverses direction insid the heater and comes out the intake instead the exhaust).

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Data insufficient to understand problem.

Stewart Warner suspects the heater was sh off without letting it purge.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B66
MODEL: C
SUPPORT SYSTEM: ENGINE FILTER
COLOR: RED

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C007	1-7-83	30,907

INCIDENT DESCRIPTION:
The heater would not operate as a result of being flooded. The fuel quick-disconnect was disconnected and the heater was allowed to run. Problem resolved. (GDLS repaired).

S-W FAILURE ANALYSIS:
N/A

CHARGEABILITY:
Not chargeable - support system.

CLOSEOUT CONSIDERATIONS:
Suspect low vehicle battery voltage.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C31
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C008	1-6-83	30,810

INCIDENT DESCRIPTION:
Heater would not start. The electrical wiring inside the heater was burned. During removal, the heater fuel pump bracket was found to be broken. The fuel pump was replaced and the heater was turned in for repair. DS found the blower motor to be burned out. The motor was replaced and the heater was operational.

S-W FAILURE ANALYSIS:
Electrical wiring in blower housing burned due to a reverse burn (fire reverses direction inside the heater and comes out the intake instead of the exhaust).

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Data insufficient to understand problem.

Stewart Warner suspects the heater was shut off without letting it purge.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B34
MODEL: C
SUPPORT SYSTEM: DAVCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C009	1-7-83	30,921

INCIDENT DESCRIPTION:
Crew was unable to start heater. GDLS mechanics removed the powerpack and found interference between the engine oil cooler lines and the rubber fuel line from the fuel supply to the heater fuel pump, resulting in a pinched fuel line. The heater fuel pump electrical connector was torn away from the pump body. The fuel lines were tied back and the fuel pump was replaced. The heater was replaced.

S-W FAILURE ANALYSIS:
No parts were recovered for analysis.

CHARGEABILITY:
Not chargeable - support system.

CLOSEOUT CONSIDERATIONS:
Design deficiency - interference fit.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B34
MODEL: C
SUPPORT SYSTEM: DAVCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C610	12-17-82-1-4-83	30,921

INCIDENT DESCRIPTION:
During powerpack installation, the engine struck the heater fuel pump creasing the pump case. Unit installed a spare pump found on vehicle B-13. This pump varies from the Davco system pump by the size of the filter screen. Davco has a 400 micron mesh where as the spare pump has a 40 micron mesh.

S-W FAILURE ANALYSIS:
N/A

CHARGEABILITY:
Not chargeable - support system.

CLOSEOUT CONSIDERATIONS:
Design deficiency - interference fit.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C34
MODEL: C
SUPPORT SYSTEM: DAVCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C011	12-22-82	30,830

INCIDENT DESCRIPTION:
Crew was unable to start heater. GDLS mechanics removed the powerpack and found interference between the engine oil cooler lines and the rubber fuel line from the fuel supply to the heater fuel pump, resulting in a pinched fuel line. The rubber lines were relocated and tied back.

S-W FAILURE ANALYSIS:
N/A

CHARGEABILITY:
Not chargeable - support system.

CLOSEOUT CONSIDERATIONS:
Design deficiency - interference fit.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: A31
MODEL: A
SUPPORT SYSTEM: ENGINE FILTER
COLOR: BLUE

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C012	1-7-83	114

INCIDENT DESCRIPTION:
During initial installation, the heater would not operate. The fuel cutoff valve in the support system was in the closed position. The valve was opened by GDLS personnel, heater functioned normally.

S-W FAILURE ANALYSIS:
No parts were replaced.

CHARGEABILITY:
Not chargeable - support system.

CLOSEOUT CONSIDERATIONS:
Maintenance error

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: A35
MODEL: A
SUPPORT SYSTEM: ENGINE FILTER
COLOR: BLUE

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C013	1-7-83	101

INCIDENT DESCRIPTION:
A fuel leak was found at a fitting on the fuel-filter. Leak caused from deletion of the teflon tape during installation. GDLS personnel made the repair.

S-W FAILURE ANALYSIS:
No parts were replaced.

CHARGEABILITY:
Not chargeable - support system.

CLOSEOUT CONSIDERATIONS:
Initial installation error by contractor personnel.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C35
MODEL: C
SUPPORT SYSTEM: DAVCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C014	1-7-83	30,964

INCIDENT DESCRIPTION:
A fuel leak was found in the engine compartment. Leak attributed to contractor installation error. (GDLS repaired).

S-W FAILURE ANALYSIS:
N/A

CHARGEABILITY:
Not chargeable - support system.

CLOSEOUT CONSIDERATIONS:
Initial installation maintenance error.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C33
MODEL: C
SUPPORT SYSTEM: DAVCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N	
C015	1-29-83	30,911	INCIDENT DESCRIPTION: Heater failed to start. Crew requested GDLS mechanics to repair. Pack was pulled, revealing pinched heater fuel lines. Lines were tied back to the bulkhead. S-W FAILURE ANALYSIS: N/A. CHARGEABILITY: Not chargeable - support system. CLOSEOUT CONSIDERATIONS: Design deficiency - interference fit.

M93 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: A31
MODEL: C
SUPPORT SYSTEM: DAYCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N	
C016	1-6-83	36,922	INCIDENT DESCRIPTION: Primary engine filter was damaged due to interference with the heater fuel pump during powerpack installation. The engine fuel filter was replaced. S-W FAILURE ANALYSIS: N/A CHARGEABILITY: Not chargeable - support system CLOSEOUT CONSIDERATIONS: Design deficiency - interference fit.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: A34
MODEL: C
SUPPORT SYSTEM: DAVCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N	
C017	1-6-83	36,916	INCIDENT DESCRIPTION: Primary engine fuel filter was damaged due to interference with the heater fuel pump during powerpack installation. The engine fuel filter was replaced.

S-W FAILURE ANALYSIS:
N/A

CHARGEABILITY:
Not chargeable - support system.

CLOSEOUT CONSIDERATIONS:
Design deficiency - interference fit.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: A18
MODEL: C
SUPPORT SYSTEM: DAVCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C018	1-6-83	30,809

INCIDENT DESCRIPTION:
Unit experienced difficulty installing the powerpack after Davco system was installed. Air induction system had to be partially removed to gain access to the Davco components to insure pack clearance.

S-W FAILURE ANALYSES:
N/A

CHARGEABILITY:
Not chargeable - support system.

CLOSEOUT CONSIDERATIONS:
Design deficiency - interference fit.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C11
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C019	1-16-83	30924

INCIDENT DESCRIPTION:
The heater would not start. The igniter was replaced but the heater still would not start. The heater was replaced.

S-W FAILURE ANALYSIS:
Igniter saturated with a soft carbon residue. After burning residue from the igniter, it was functional.

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Data insufficient to understand problem.

GDLS suspects the heater was merely flooded.

Stewart Warner believes the heater was either operating with rich fuel or there was a low voltage condition on the tank when the crew attempted to start the heater.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B25
MODEL: C
SUPPORT SYSTEM: ENGINE FILTER
COLOR: RED

INCIDENT NO.	INCIDENT DATE	HEATER S/N	
C029	1-19-83	30,920	

INCIDENT DESCRIPTION:
The heater was not putting out any hot air. The igniter would not ignite. The igniter was replaced.

S-W FAILURE ANALYSIS:
Igniter found to be operational during failure analysis.

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Data insufficient to understand problem.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B65
MODEL: C
SUPPORT SYSTEM: ENGINE FILTER
COLOR: RED

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C021	1-16-83	30,905

INCIDENT DESCRIPTION:
Fuel pump comes on but the fan does not. Igniter was found to be shorted. Igniter was replaced. Heater operated.

S-W FAILURE ANALYSIS:
Returned igniter is not a Stewart-Warner part. The report that the motor did not turn is normal with a shorted igniter.

CHARGEABILITY:
Secondary failure - trash in fuel screen.

CLOSEOUT CONSIDERATIONS:
Suspect ignition circuit failure as secondary to long starting cycle. Debris suspected to be teflon tape was found on the inlet fuel screen to the fuel regulator valve.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B65
MODEL: C
SUPPORT SYSTEM: DAVCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C021A	1-23-85	30,905

INCIDENT DESCRIPTION:
The heater would not ignite. The heater was replaced.

S-W FAILURE ANALYSIS:
The flame detector switch was found to be operational after adjustment. The igniter was shorted. The ignition control was burned out.

CHARGEABILITY:
Secondary failure - trash in fuel screen.

CLOSEOUT CONSIDERATIONS:
Suspect ignition circuit failure as secondary to long starting cycle. Debris suspected to be teflon tape was found on the inlet fuel screen to the fuel regulator valve.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B24
MODEL: C
SUPPORT SYSTEM: ENGINE FILTER
COLOR: RED

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C022	1-17-83	30,792

INCIDENT DESCRIPTION:
Heater would only operate with the tank running. When tank was shut off, 4 to 5 minutes later the heater fan shut off and the igniter burned out. Possibly a bad fuel pump. Igniter was replaced.

S-W FAILURE ANALYSIS:
Igniter is not a Stewart-Warner part. Tank had a faulty fuel pump discovered by GD personnel, Mr. J. Vanwingerden.

CHARGEABILITY:
Secondary failure - see incident C047.

CLOSEOUT CONSIDERATIONS:
Suspect ignition circuit failure as secondary to long starting cycle caused by a no fuel condition (shorted fuel pump).

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B32
MODEL: C
SUPPORT SYSTEM: ENGINE FILTER
COLOR: RED

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C023	1-19-63	30,903

INCIDENT DESCRIPTION:
Heater would not operate unless the vehicle fuel pumps were turned on. Serviceable ignition control was removed from this heater and installed in the heater in vehicle B31 during a field problem.

S-W FAILURE ANALYSIS:
Ignition control burned out.

CHARGEABILITY:
Chargeable - support system.

CLOSEOUT CONSIDERATIONS:
Inoperative heater fuel pump.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B22
MODEL: C
SUPPORT SYSTEM: ENGINE FILTER
COLOR: RED

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C024	1-20-83	30,908

INCIDENT DESCRIPTION:
Heater fan came on with no hot air present. Igniter was found to be burned out. Igniter was replaced.

S-W FAILURE ANALYSIS:
No parts were recovered for analysis.

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Failed igniter.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B52
MODEL: C
SUPPORT SYSTEM: ENGINE FILTER
COLOR: RED

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C025	1-18-83 1-22-83	30,906

INCIDENT DESCRIPTION:
Heater fuel line was leaking. Fuel line was tightened. Four days later the igniter was burned out.

S-W FAILURE ANALYSIS:
No parts were recovered for analysis.

CHARGEABILITY:
Fuel leak - chargeable - support system.
Igniter - chargeable - heater.

CLOSEOUT CONSIDERATIONS:

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B31
MODEL: C
SUPPORT SYSTEM: DAVCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C026	1-21-83	30,922

INCIDENT DESCRIPTION:
Heater fuel system was damaged durin powerpack installation. The system wa repaired. No details were given on type o extent of damage.

S-W FAILURE ANALYSIS:
N/A

CHARGEABILITY:
Not chargeable - support system.

CLOSEOUT CONSIDERATIONS:
Design deficiency - interferance fit.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NC.: B31
MODEL: C
SUPPORT SYSTEM: DAVCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C027	1-20-83	Unk
	1-21-83	

INCIDENT DESCRIPTION:
Heater was flooded and would not start. Fuel supply disconnected and heater purged. Heater operated.
Heater would not start. Replaced igniter and ignition control. Replaced inoperative fuel pump.

S-W FAILURE ANALYSIS:
Ignition control burned out. Igniter also burned out but not returned.
Ignition control failure is a secondary failure and is caused by start periods much greater than five minutes with a shorted igniter. Igniter failed due to starting without fuel. It is not common practice that the tank crews bleed fuel lines after service. The fuel pump was nonoperational.

CHARGEABILITY:
Chargeable, heater.
Secondary heater failure - see C026.

CLOSEOUT CONSIDERATIONS:
Suspect ignition circuit failure as secondary to long starting cycle.
Secondary failure attributed to long start attempts without fuel available at the heater (see C026).

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C31
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C028	1-7-83	30,910
	Duplicate of EPR C008	

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B34
MODEL: C
SUPPORT SYSTEM: DAVCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C029	1-7-83	30,921
	Duplicate of EPR C009	

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: A11
MODEL: A
SUPPORT SYSTEM: ENGINE FILTER
COLOR: BLUE

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C039	1-12-83	115

INCIDENT DESCRIPTION:
Crew stated there was smoke coming from the heater and it failed to operate on the low setting. The heater was pulled, it operated normally on the test stand at DS maintenance. Replacement heater worked fine on both hi and low settings. Problem could not be isolated.

S-W FAILURE ANALYSIS:
No parts were replaced.

CHARGEABILITY:
Chargeable - support system.

CLOSEOUT CONSIDERATIONS:
The smoke from the heater was caused by a crew member turning the heater off while it was running. Interviews with the crew revealed they had repaired the DIF heater switch and wiring.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: A13
MODEL: C
SUPPORT SYSTEM: DAVCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C031	1-8-83	30,902

INCIDENT DESCRIPTION:
On first start attempt, had a backfire and then failed to start. Heater was replaced.

S-W FAILURE ANALYSIS:
Shorted igniter and open ignition control failed due to long start attempt.

CHARGEABILITY:
Chargeable - support system.

CLOSEOUT CONSIDERATIONS:
Suspect ignition circuit failure as secondary to long starting cycle. Stewart Warner questions whether fuel was available at the heater due to frequent fuel line pinching incidents with the DAVCO system.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B65
MODEL: C
SUPPORT SYSTEM: ENGINE FILTER
COLOR: RED

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C032	12-18-62	30,905
	12-23-62	

INCIDENT DESCRIPTION:
Heater would not start. Igniter was replaced and heater was operational.
Five days later the heater would not start. Igniter was replaced. Heater still would not start.

S-W FAILURE ANALYSIS:

CHARGEABILITY:
Igniter (12-18-62) - Secondary failure - see incident C021.

Igniter 12-23-62 - Secondary failure - see incident C021.

CLOSEOUT CONSIDERATIONS:
See EPR C021.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B21
MODEL: C
SUPPORT SYSTEM: DAVCO
COLOR: YELLOW

INCIDENT NO.	DATE	HEATER S/N
C033	1-24-83	30,925

INCIDENT DESCRIPTION:
The heater would not start. The heater was replaced.

S-W FAILURE ANALYSIS:
Igniter control open, igniter shorted and overheat switch shorted.

CHARGEABILITY:
Chargeable heater.

CLOSEOUT CONSIDERATIONS:
Improper adjustment of overheat switch at the crew or organizational level. Some type of heater malfunction had to precede the adjustment.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C25
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C034	1-23-85	30836

INCIDENT DESCRIPTION:
Heater would not start. The crew replaced the igniter but the heater still would not start. DS replaced the burner and the igniter. The igniter was missing when heater was turned in to DS.

S-W FAILURE ANALYSIS:
It was not possible to fully analyze the burner. The burner had been partially disassembled and shipped unwrapped in a box of loose parts. The vaporizer did not have an excessive amount of carbon and the wick appeared functional.

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Data insufficient to understand problem.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C22
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N	
C035	1-23-83	30827	INCIDENT DESCRIPTION: Heater would ignite, but fan would not come on to high speed and light on panel would not light. The heater was replaced. S-W FAILURE ANALYSIS: Flame detector switch found to be operational after adjustment. CHARGEABILITY: Chargeable - heater. CLOSEOUT CONSIDERATIONS:

M63 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C34
MODEL: C
SUPPORT SYSTEM: DAVCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C036	1-24-83	30,830

INCIDENT DESCRIPTION:
Heater does not purge and the high speed fa
will not engage. Panel light does not come or
Heater was replaced.

S-W FAILURE ANALYSIS:
Flame detector switch misadjusted and bracke
bent.
Switch found to be operational if placed in
new bracket.

CHARGEABILITY:
Not chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Maintenance error. Tank Commander told
Stewart Warner representative he believed th
flame detector switch was a thermostat b
which he could regulate the heater output.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C35
MODEL: C
SUPPORT SYSTEM: DAVCC
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C037	2-1-83	30,904

INCIDENT DESCRIPTION:
Heater caught on fire and was put out with a fire extinguisher. Heater would not restart. Replaced heater. Received at DS maintenance without igniter and ignition control.

S-W FAILURE ANALYSIS:
Flame detector switch found to be operational after adjustment. Heater may have backburned and smoked out the inlet.

Flame detector switch misadjusted.

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Data insufficient to understand problem.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C33
MODEL: C
SUPPORT SYSTEM: DAVCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C038	1-23-83	30,911

INCIDENT DESCRIPTION:
Heater purged out by itself and would not start. Heater was replaced. When turned in to DS the igniter and ignition control were missing.

S-W FAILURE ANALYSIS:
Purging out by itself is either caused by lack of fuel or actuation of overheat switch. This returned flame detector switch does not have 149 hours of use as determined by discoloration of the ceramic rod. This flame detector switch has less than 20 hours of operation. However, this flame detector switch does not work due to contact wear caused by poor microswitch quality.

Microswitch has poor factory quality. Heater malfunction undetermined.

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Quality problem with flame detector switch microswitch corrected at vendor 12-1-82.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C31
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C039	2-9-83	30,831

INCIDENT DESCRIPTION:
Heater would not start. The igniter was replaced.

S-W FAILURE ANALYSIS:
Carbon deposit on shorted igniter coil.

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Data insufficient to understand the problem.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C15
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C040	1-21-33	30926

INCIDENT DESCRIPTION:
Heater was back firing and would not start. The heater was replaced.

S-W FAILURE ANALYSIS:
1) Contaminated fuel valve caused very low fuel flow rates. Rates returned to normal after the valve was cleaned.

2) Shutoff solenoid on fuel valve damaged due to handling. (Suspect shipping damage after part failed.)

CHARGEABILITY:
Chargeable - support system.

CLOSEOUT CONSIDERATIONS:
Possible fuel contamination.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B61
MODEL: C
SUPPORT SYSTEM: ENGINE FILTER
COLOR: RED

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C041	3-7-83	30,906

INCIDENT DESCRIPTION:
Crew reported heater has fuel to the carburetor but fuel will not come out of the bleeder valve. Suspect plugged carburetor. Heater replaced.

S-W FAILURE ANALYSIS:
1. Fuel valve very dirty. Fuel rates about 1/2 of nominal.
2. Terminal on shut-off solenoid broken.

The flame detector switch was found to be operational. There was a burn mark on the plastic housing on the normally closed contacts. The heat was generated outside the switch. However, it only affected the cosmetics of the switch. The ignition control was burned out. Carbon build up in vaporizer pad around fuel spud.

CHARGEABILITY:
Chargeabe - support system.

CLOSEOUT CONSIDERATIONS:
According to Stewart Warner, all four of the failed components were a result of a low fuel flow rate caused by contaminated fuel.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C11
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C042	3-4-83	30,833

INCIDENT DESCRIPTION:
The heater would not start. The fan would not come on. The wire lead to the heater blower motor was cut. Heater was replaced.

S-W FAILURE ANALYSIS:
No parts were replaced.

CHARGEABILITY:
Not chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Isolated failure.

Stewart Warner operates every production heater for 45 minutes prior to final acceptance. The wire must have been cut after it left the factory.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C66
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C043	12-25-82	30,822

INCIDENT DESCRIPTION:
Heater starts then shuts off - floods out. Heater replaced.

S-W FAILURE ANALYSIS:
Ignition control burned out.

System starting and shutting off is usually caused by fuel starvation. The heater will cool down and return to the start circuit automatically. After the heater fails to start, it will flood due to a low flow rate or when fuel is restored after the start circuit is damaged.

CHARGEABILITY:
Chargeable - support system.

CLOSEOUT CONSIDERATIONS:
Suspect ignition circuit failure as secondary to long starting cycle.

Stewart Warner suspects contaminated vehicle fuel.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C32
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C044	3-7-83	30,832

INCIDENT DESCRIPTION:
The heater would not start. The igniter was replaced. Heater functioned normally.

S-W FAILURE ANALYSIS:
Carbon found on the face of the igniter coil. Carbon build-up on burner assembly. Primary failure undeterminable.

CHARGEABILITY:
Secondary Failure - see C061.

CLOSEOUT CONSIDERATIONS:
Suspect ignition circuit failure as secondary to long starting cycle.

Incident connected with C051, faulty flame detector switch.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B11
MODEL: C
SUPPORT SYSTEM: ENGINE FILTER
COLOR: RED

INCIDENT NO.	INCIDENT DATE	HEATER S/N	
C045	1-20-83	30,819	INCIDENT DESCRIPTION: Heater would not start due to a failed igniter. The igniter was replaced. S-W FAILURE ANALYSIS: Igniter shorted. CHARGEABILITY: N/A - Refer to incident C049. CLOSEOUT CONSIDERATIONS:

M50 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: A65
MODEL: A
SUPPORT SYSTEM: ENGINE FILTER
COLOR: BLUE

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C046	2-18-83	108

INCIDENT DESCRIPTION:
Heater would not start due to an inoperative fuel pump. The heater fuel pump was replaced. Heater was then operational.

GDLS FAILURE ANALYSIS:
Electrical leads were intact and in good condition. Electrical power applied and pump was functional. Stewart Warner indicates the heater fuel pump has an internal check valve which prevents the engine fuel pumps from pumping fuel through the heater fuel pump if the lines were connected backwards.

CHARGEABILITY:
Changeable - support system.

CLOSEOUT CONSIDERATIONS:
Suspect heater fuel pump was inoperative due to a loose or disconnected electrical connector.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B24
MODEL: C
SUPPORT SYSTEM: ENGINE FILTER
COLOR: RED

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C047	2-16-83	30,792

INCIDENT DESCRIPTION:
The heater would operate only with the tank running. The heater fuel pump was found to be defective and was replaced.

GDLS FAILURE ANALYSIS:
Pump internally short circuited. Head build-up noted where power lead enters pump case. Coil insulation observed to be totally charred indicating the malfunction occurred somewhere in the coil structure possibly due to insulation breakdown. Problem possibly caused during production process where the varnish insulation was damaged.

CHARGEABILITY:
Chargeable - support system.

CLOSEOUT CONSIDERATIONS:
Shorted fuel pump.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: A18
MODEL: C
SUPPORT SYSTEM: DAVCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C048	2-16-83	30,825
	3-13-83	

INCIDENT DESCRIPTION:
Heater failed to start. Replaced igniter.
3-13-83. Heater failed to start. Replaced heater.

S-W FAILURE ANALYSIS:
Failed flame detector switch.

Stewart Warner technical representative was present at DS maintenance for the heater repair and had access to all replaced components for failure analysis.

CHARGEABILITY:
Secondary failure - see below.
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
First igniter failure was secondary to faulty flame detector switch (second failure).

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B11
MODEL: C
SUPPORT SYSTEM: ENGINE FILTER
COLOR: RED

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C049	3-23-83	30,919

INCIDENT DESCRIPTION:
Organization attempted to repair inoperative heater by replacing the heater switch on the DIP. Heater was still inoperative at end of test. ANAD repaired heater but repair action was not recorded.

S-W FAILURE ANALYSIS:
No parts were recovered for analysis.

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Data insufficient to understand problem.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B12
MODEL: C
SUPPORT SYSTEM: ENGINE FILTER
COLOR: RED

INCIDENT NO.	INCIDENT DATE	HEATER S/N	
C050	3-23-83	30,918	INCIDENT DESCRIPTION: Heater was found to be inoperative at end of test. ANAD repaired heater but repair action was not recorded. S-W FAILURE ANALYSIS: No parts were recovered for analysis. CHARGEABILITY: N/A CLOSEOUT CONSIDERATIONS: All test data pertaining to this vehicle was deleted since the contractor was not able to functionally check the heater following initial installation. Heater accumulated only one start and one heater hour during the entire test.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B21
MODEL: C
SUPPORT SYSTEM: DAVCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C051	3-23-83	30,83[illegible]

INCIDENT DESCRIPTION:
Heater discovered inoperative at end of test. ANAD personnel replaced igniter and flame detector switch.

S-W FAILURE ANALYSIS:
Igniter shorted.

Secondary failure due to faulty microswitch.

Microswitch is faulty due to the lever and pin fitting excessively tight. No pitting or burning of the contacts was noted.

Microswitch quality problem.

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Quality problem with flame detector switch microswitch corrected at vendor 12-1-[illegible]

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B24
MODEL: C
SUPPORT SYSTEM: ENGINE FILTER
COLOR: RED

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C052	3-17-83	30,906

INCIDENT DESCRIPTION:
Crew reported heater starts but blows cold air. Heater removed by ANAD personnel at end of test.

S-W FAILURE ANALYSIS:
Stewart Warner technical representative was present at DS maintenance for the heater repair and had access to all replaced components for failure analysis. Igniter was shorted. The condition of the burner was not determined.

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Data insufficient to understand problem.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B32
MODEL: C
SUPPORT SYSTEM: ENGINE FILTER
COLOR: RED

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C053	3-14-83	30,826

INCIDENT DESCRIPTION:
Heater found inoperative at end of test. Replaced by ANAD personnel.

S-W FAILURE ANALYSIS:
Stewart Warner technical representative was present at DS maintenance for the heater repair. No parts were replaced.

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Flame detector switch out of adjustment.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B34
MODEL: C
SUPPORT SYSTEM: DAYCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C054	3-23-83	30,819

INCIDENT DESCRIPTION:
Heater discovered inoperative at end of test. ANAD repaired heater but repair action was not recorded.

S-W FAILURE ANALYSIS:
No parts were recovered for analysis. Stewart Warner inspected the heater on 23 March 1983 and identified the flame detector switch to be faulty.

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Faulty flame detector switch.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C15
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C059	3-11-83	30,838

INCIDENT DESCRIPTION:
Heater was discovered inoperative at end of test. ANAD personnel replaced igniter and flame detector switch.

S-W FAILURE ANALYSIS:
Microswitch (part of flame detector switch) is faulty due to the lever and pin fitting excessively tight. No pitting or burning of the contacts was noted.
Microswitch quality problem.

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Quality problem with flame detector switch microswitch corrected by Stewart Warner at vendor 12-1-82.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B65
MODEL: C
SUPPORT SYSTEM: ENGINE FILTER
COLOR: RED

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C056	1-23-83	30,903

INCIDENT DESCRIPTION:
This operational replacement heater obtained by DX from EPR C021 was never installed in the tank by the unit. During end of test operations, ANAD personnel completed the installation.

S-W FAILURE ANALYSIS:
N/A

CHARGEABILITY:
N/A

CLOSEOUT CONSIDERATIONS:
Not a failure.

M.O HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B52
MODEL: C
SUPPORT SYSTEM: ENGINE FILTER
COLOR: RED

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C055	3-23-83	30,905

INCIDENT DESCRIPTION:
This replacement heater obtained by DX from EPR C041 was never installed in the tank by the unit. During end of test operations, ANAD personnel attempted to operate the heater without results. The heater was replaced.

S-W FAILURE ANALYSIS:
Stewart Warner technical representative was present at DS maintenance for the heater repair and had access to the replaced fuel regulator for failure analysis. Their onsite inspection showed contaminated fuel.

CHARGEABILITY:
Not chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Although dirt was found on the fuel regulator inlet screen, this heater was never installed in the tank. Unknown how the dirt was deposited on the screen.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C12
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C058	3-23-83	30,651

INCIDENT DESCRIPTION:
Heater was found to be non-operational at end of test (starts on "High" only). ANAD personnel replaced the flame detector switch.

S-W FAILURE ANALYSIS:
Flame detector switch operational after adjustment. No pitting or burning noted on the contacts.

CHARGEABILITY:
Chargeable - heater.*

CLOSEOUT CONSIDERATIONS:
Date insufficient to understand problem.

*Stewart Warner contends the symptoms indicate a problem with the heater switch on the DIP, not the flame detector switch. When the heater switch is set to "HIGH-ON", the heater still must start on low and cross over to high.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C11
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C057	3-23-83	30,830

INCIDENT DESCRIPTION:
The heater was discovered to be non-operational at end of test. ANAD personnel replaced the heater.

S-W FAILURE ANALYSIS
Stewart Warner technical representative was present at DS maintenance for the heater repair. Inspection showed the flame detector switch was out of adjustment.

CHARGEABILITY:
Not chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Mis-adjustment of flame detector switch will cause ignition failures.

The flame detector switch was not properly adjusted during a previous DS maintenance repair.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C31
MODEL: [illegible]
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C060	3-23-83	30,831

INCIDENT DESCRIPTION:
Heater was found inoperative at end of test. ANAD personnel replaced the heater.

S-W FAILURE ANALYSIS:
Stewart Warner technical representative was present at DS maintenance for the heater repair and had access to all replaced components for failure analysis.

Onsite analysis showed improper overheat switch adjustment. Ceramic rod was missing from the switch.

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Data insufficient to understand problem.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C32
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C061	3-23-83	30,832

INCIDENT DESCRIPTION:
Heater discovered inoperative at end of test. ANAD personnel replaced igniter and flame detector switch.

S-W FAILURE ANALYSIS:
Shorted igniter.
Secondary failure due to faulty microswitch.
Microswitch is faulty due to the lever and pin fitting excessively tight. No pitting or burning of the contacts was noted.
Microswitch quality problem.

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Quality problem with flame detector switch microswitch corrected at vendor 12-1-82.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C33
MODEL: C
SUPPORT SYSTEM: DAVCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C062	3-23-83	30,820

INCIDENT DESCRIPTION:
Heater discovered inoperative at end of test. ANAD personnel replaced heater.

S-W FAILURE ANALYSIS:
Stewart Warner technical representative was present at DS maintenance for the heater repair and had access to all replaced components for failure analysis. An analysis was not conducted.

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Data insufficient to understand problem.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C35
MODEL: C
SUPPORT SYSTEM: DAVCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C063	3-23-83	30,911

INCIDENT DESCRIPTION:
Heater discovered inoperative at end of test. ANAD personnel replaced heater.

S-W FAILURE ANALYSIS:
Stewart Warner technical representative was present at DS maintenance for the heater repair and had access to all replaced components for failure analysis. Igniter was shorted. Burner was not analyzed.

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Data insufficient to understand problem.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C53
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C064	3-11-83	30,824

INCIDENT DESCRIPTION:
Heater would not start. ANAD personnel replaced igniter, flame detector switch, and ignition control.

S-W FAILURE ANALYSIS:
Microswitch is faulty due to the lever and pin fitting excessively tight. No pitting or burning of the contacts was noted.
Microswitch quality problem.
Shorted igniter. Secondary failure due to faulty flame detector.
Burned out.
Secondary failure caused by excessively long start periods with a shorted igniter.

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Quality problem with microswitch corrected at vendor 12-1-82.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C66
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C065	3-16-83	30,910

INCIDENT DESCRIPTION:
Heater would not start. ANAD personnel replaced the heater at end of test.

S-W FAILURE ANALYSIS:
Stewart Warner technical representative was present at DS maintenance fo the heater repair and had access to the replaced component for failure analysis. An analysis was not conducted.

CHARGEABILITY:
Chargeable - support system.

CLOSEOUT CONSIDERATIONS:
Suspect fuel contamination.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: B24
MODEL: C
SUPPORT SYSTEM: ENGINE FILTER
COLOR: RED

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C066	1-10-83	30,792

INCIDENT DESCRIPTION:
Heater would not start due to a failed igniter. The igniter was replaced.

S-W FAILURE ANALYSIS:
Shorted igniter.

CHARGEABILITY:
Secondary failure - see incident C047.

CLOSEOUT CONSIDERATIONS:
Suspect ignition circuit failure as secondary to long starting cycle caused by a no fuel condition (shorted fuel pump).

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: A35
MODEL: A
SUPPORT SYSTEM: ENGINE FILTER
COLOR: BLUE

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C067	3-23-83	30,926

INCIDENT DESCRIPTION:
DS spare model "C" heater used to replace a model "A" at end of test would not start, igniter was replaced.

S-W FAILURE ANALYSIS:
Shorted igniter. Carbon deposits on face of coil. Secondary failure to carbon build up in burner assembly.

CHARGEABILITY:
N/A

CLOSEOUT CONSIDERATIONS:
Not a test item.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C32
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C068	1-26-83	30,832

INCIDENT DESCRIPTION:
Heater kicked on low speed when starting. Floods out. Microswitch will turn fan to high speed. On 2-1-83 let heater purge with fuel line disconnected. Heater was then operational

S-W FAILURE ANALYSIS:
No parts were replaced.

CHARGEABILITY:
Secondary failure - see C061.

CLOSEOUT CONSIDERATIONS:
Faulty flame detector switch.

M59 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: [illegible]
MODEL: C
SUPPORT SYSTEM: ENGINE HEATER
COLOR: RED

INCIDENT NO.	INCIDENT DATE	HEATER S/N	
C045	3-6-83	30,751	INCIDENT DESCRIPTION: Problem not indicated. Crew replaced heater while at tank gunnery.

S-W FAILURE ANALYSIS:
Stewart Warner technical representative was present at DS maintenance for the heater repair and had access to all replaced components for failure analysis.

CHARGEABILITY:
Secondary failure - see incident C047.

CLOSEOUT CONSIDERATIONS:
Suspect ignition circuit failure as secondary to long starting cycle caused by a no fuel condition (shorted fuel pump).

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: A34
MODEL: C
SUPPORT SYSTEM: DAVCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N	
C070	3-11-83	30,916	INCIDENT DESCRIPTION: Heater would not start. Crew removed heater but it was lost before it could be repaired. ANAD installed replacement heater. S-W FAILURE ANALYSIS: N/A CHARGEABILITY: Chargeable - heater. CLOSEOUT CONSIDERATIONS: Data insufficient to understand problem -heater lost.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: A31
MODEL: A
SUPPORT SYSTEM: ENGINE FILTER
COLOR: BLUE

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C071	3-14-83	114

INCIDENT DESCRIPTION:
Blower would not come on. Clicking noise heard. No repairs were made. Heater was found to be operational on 23 March by GDLS after the crew had jump started the tank and replaced one of the vehicle batteries.

S-W FAILURE ANALYSIS:
No parts were replaced.

CHARGEABILITY:
Not chargeable - support system.

CLOSEOUT CONSIDERATIONS:
Heater failed to start due to low vehicle battery voltage. The model "A" heater will not pull in the blower when vehicle voltage is less than 18 volts.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C34
MODEL: C
SUPPORT SYSTEM: DAVCO
COLOR: YELLOW

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C074	2-15-83 (estimated)	30,921

INCIDENT DESCRIPTION:
Problem not reported. Unit replaced heater. Heater lost prior to repair.

S-W FAILURE ANALYSIS:
N/A.

CHARGEABILITY:
Not chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Heater lost before repairs.

M60 HEATER SYSTEM TEST
FORT CARSON

VEHICLE NO.: C25
MODEL: C
SUPPORT SYSTEM: STANDARD
COLOR: BLACK

INCIDENT NO.	INCIDENT DATE	HEATER S/N
C075	3-13-83	30,923

INCIDENT DESCRIPTION:
Heater backfired (loud bang), much smoke, shut itself off. Could not restart. Crew repaired.

S-W FAILURE ANALYSIS
No parts were recovered for analysis.

CHARGEABILITY:
Chargeable - heater.

CLOSEOUT CONSIDERATIONS:
Data insufficient to understand problem.

DEPARTMENT OF THE ARMY
UNITED STATES ARMY TANK-AUTOMOTIVE COMMAND
WARREN, MICHIGAN 48090

16 MAY 1983

DRCPM-M60-E

SUBJECT: Minutes of the 5 May 1983 EPR Close-Out Conference - M60 Tank Heater Comparison Test

SEE DISTRIBUTION

1. A final EPR Close-Out Conference for the Ft Carson Heater Comparison Test was conducted at the offices of PM, M60 on 5 May 1983.

2. A list of attendees is attached as enclosure 1.

3. Major Rogers opened the conference with an introduction of the participants and a discussion of the scope and objectives of the meeting. Each EPR was to be addressed in the following sequence:

Summarize Incident (Rogers/Ashley)
Present Failure Analysis (Stewart Warner/GDLS)
Proposed Close-Out Statement (GDLS)
Discussion
Accept or Modify Close-Out
Agree on Chargeability (no formal voting)

4. A complete record of the conference actions have been included as Appendix F to the PM, M60 Final Test Report (TACOM Technical Report #12759). Due to the bulk of this material, copies are not attached to these minutes.

5. Major Rogers discussed the status of the test report and draft copies of the text were distributed for comments. GDLS will print the report for PM, M60.

DRCPM-M60-E
SUBJECT: Minutes of the 5 May 1983 EPR Close-Out Conference - M60 Tank Heater Comparison Test

6. Stewart Warner commented that during their visit to DS Maintenance, they noticed several repaired heaters which were missing the rubber gromet above the igniter.

FOR THE COMMANDER:

RONALD M. MCCULLOUGH
C, Tech Mgt Div

1 Encl
as

DISTRIBUTION:

USTACOM, DRSTA-GBT.5 (Heater Working Group)
" DRCPM-M60-E (6 cys)
" DRCPM-M60-Q
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" DRSTA-GBM
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General Dynamics Land Systems
Division, Mr. Jack VanWingerden
Mr. Ron Smith
Mr. Paul Mento
Mr. R.S. Eaton
Mr. Ernie Stanko
Mr. Harold Anderson
Mr. Larry Bryan
Mr. Phil Erickson
Mr. Frank Purczynski
Stewart Warner Corporation

HEATER EPR CLOSE-OUT CONFERENCE
5 MAY 1983

ATTENDEES:

NAME	REPRESENTING	TELEPHONE
Maj Jeff Rogers	PM, M60-E	313-574-6732
Bill Ashley	PM, M60-E	313-574-6746
Gary Robbins	DRSTA-GBM	313-574-5885
Donald G. Burkhart	DRSTA-GBT	313-574-6112
Rudy Stumpp	Stewart-Warner	317-632-8411
T.W. Sutterfield	Stewart-Warner	317-267-1642
C.F. Jirkovsky	PM, M60-L	313-786-4816
Jack VanWingerden	GDLS	313-978-5380
R. Smith	GDLS	313-497-7190
Paul Mento	GDLS	313-497-7614
R.S. Eaton	GDLS	313-497-7176
E.S. Stanko	GDLS	313-497-7238
G.J. Varela	DRCPM-M60, USMC-LNO	313-574-6831
T. Learmont	DRCPM-M60-Q	313-574-6747
H.R. Anderson	GDLS	313-497-7159
Larry Bryan	GDLS	313-583-5747
Phil Erickson	GDLS	313-497-7027
Frank Purczynski	GDLS	313-497-7132
C. Vanderzon	PM, M60-E	313-574-6743

APPENDIX G

SUMMARY OF TEST DATA

ALL FAILED OR REPAIRED HEATER OR HEATER SUPPORT SYSTEM COMPONENTS

	Blue System	Red System	Yellow System	Black System
Igniter		𝍸 𝍸 II	𝍸 𝍸 I	𝍸 IIII
Flame Detector Switch		IIII	𝍸 III	𝍸 𝍸 II
Ignition Control		III	𝍸 II	III
Heater Fuel Pump	I	I	III	I
Fuel Regulator		II		II
Burner/Wick		III	I	II
Fuel Line	I	I	I	
Overheat Switch			I	I
Circuit Board ("A" heater)	I			
Repair Vehicle Wiring	I			I
Blower Motor				I
Totals	4	26	32	32
Chargeable	2	13	22	26
$\bar{X}$ (Chargeable)	0.2	1.4	2.4	2.6

BLUE SYSTEM (9 VEHICLES)*

C = Chargeable
NC = Not chargeable
S = Secondary failure
E = Estimated
X = Average per vehicle

(9 Vehicles)

Tank Bumper Number	Heater %N	Heater Starts	Heater Hours	Tank Miles	Failures (Initial Installation) Heater C/NC/S	Failures (Initial Installation) Spt Sys C/NC/S	Failures (In Service) Heater C/NC/S	Failures (In Service) Spt Sys C/NC/S	EPR #	Failure Description (Corrective Action)
A8	115	23	56	178				C	C833	No low/Elec short/smoking (Rewired DIP & switch)
	118	59	153	96						
A15	105	95(E)	225	487						
A27	118	75(E)	442	458						
A31	114	102	201	399		NC			C805	Crew error - water found in heater exhaust pipe. Resistor heat & cracked (repl circuit board).
								NC	C812	Fuel shutoff valve closed (opened)-maintenance error.
								NC	C871	Fan wouldn't kick on-vehicle voltage problem.
A32	103	84	125	327(E)						
A35	101	121	152(E)	148		NC			C813	Fuel leak (installed teflon tape).
A51	113	82	81	85						
A65	108	83(E)	464	435				C	C866	HTR only ran w/engine on heater (heater fuel pump inop. due to disconnected electrical wiring).
A66	106	45(E)	211	305						
Totals	18	773	2148	2945		2NC		2NC 2C		
X	1.1	47	136	327						
HOURS START			2.7							

*Note 1: Tank A13 was eliminated from test data. No heater failures, 8.4 heater hours, 8 vehicles miles.
2: Alpha company spent approximately 30% more time in the field than Bravo or Charlie Company.

RED SYSTEM (9 VEHICLES)*

C = Chargeable
NC = Not chargeable
S = Secondary failure
E = Estimated
$\bar{X}$ = Average per vehicle

(9 Vehicles)

Tank Bumper Number	Heater SN	Heater Starts	Heater Hours	Tank Miles	Failures (Initial Installation) Heater C/NC/S	Failures (Initial Installation) Spt Sys C/NC/S	Failures (In Service) Heater C/NC/S	Failures (In Service) Spt Sys C/NC/S	EPR #	Failure Description (Corrective Action)
B11	30919	12	11	335	NA	NA	NA	NA	C046	(Igniter & Htr SW) (Did not solve problem)
							C		C049	(Unk)
B15	30793	16	58	80						
B22	30908	28	294(E)	370			C		C024	No Heat (Igniter)
B24	30792	12	177	200			S		C066	Failed fuel pump caused failure (Igniter)
							S		C022	Failed fuel pump caused failure (Igniter)
								C	C047	(Fuel pump & igniter)
							S		C069	Failed fuel pump caused failure. (Purged, ignition control, flame DET SW, & burner/wick)
	30906	1	16	81			C		C052	(Burner & Igniter)
B25	30920	18(E)	183	153			C		C020	(Igniter)
B32	30903	23	59(E)	130				C	C023	Heater will not run without tank fuel pumps (purged - suspect faulty fuel pump)
	30826	18	99	101			C		C053	(Adjusted FL DET SW & purged)
B52	30906	18	191	150				C	C025	Fuel leak (tightened)
							C		C025	(Igniter)
								C	C041	Heater fuel valve plugged (suspect contaminated fuel) (Burner/wick FL DET SW, fuel regulator, voltage limiter, purged)
	30905	0	0	95	NA	NA	NA	NA	C055	Never installed in vehicle.
B65	30905	22	142	185			S		C032	Teflon tape caused failure. (Igniter)
							S		C032	Teflon tape caused failure (Igniter)
							S		C021	Teflon tape caused failure (Igniter)
								NC	C021	(Purged, FL DET SW, ignition control, igniter, fuel regulator)
	30903	0	0	100	NA	NA	NA	NA	C056	Never installed in vehicle (Heater installed)
B66	30907	11(E)	79	80		NC			C007	Flooded (purged - suspect low vehicle voltage)
Totals	13	179	1309	2080			6C	4C		
$\bar{X}$	1.4	20	145	231		1 NC	6S	1NC		
HOURS/START			7.3							

*Tank B12 was eliminated from test data. Although the heater never started during the test, the contractor was unable to conduct a functional check of the test hardware during initial installation.

YELLOW SYSTEM (9 VEHICLES)

C = Chargeable
NC = Not chargeable
S = Secondary failure
E = Estimated
X = Average per vehicle

(9 Vehicles)

Tank Bumper Number	Heater SN	Heater Starts	Heater Hours	Tank Miles	Failures (Initial Installation) Heater C/NC/S	Failures (Initial Installation) Spt Sys C/NC/S	Failures (In Service) Heater C/NC/S	Failures (In Service) Spt Sys C/NC/S	EPR #	Failure Description (Corrective Action)
A13	30,909	0	2	10	C	NC			C018	Pack interference
									C031	No start (purged adjusted Ft. DET. SW, igniter, ignition control).
	30,825	1	4	509			S		C048	Failed flame detector switch caused failure (igniter)
							C		C048	No start (purged, FL DET. SW, ignition control)
A22	30,928	91	281	256		NC			C016	Pack interference (repl engine filter)
A34	30,916	88	155	435		NC			C017	Pack interference (repl engine filter)
							C		C070	No start (igniter)
B21	30,925	15	113	194			C		C033	Heater would only run with fan running. (Heater lost) No start (purge, adj FL DET. SW, igniter, ignition control, over-heat SW)
	30,835	10	211	140			C		C051	No start (igniter, flame DET. SW)
B31	30,922	14(E)	86	175			S		C027	Damaged fuel pump caused failure (purged)
								NC	C026	No start (igniter, voltage limiter, heater fuel pump unknown repairs to fuel system in engine compartment)
B34	30,921	0	3	5(E)	S				C004	Pinched fuel lines caused failure (purged, igniter)
						NC			C010	Pack interference (Heater fuel pump)
						NC			C009	Fuel lines pinched (tied back & heater fuel pump & igniter)
	30,819	12	167	90(E)			C		C054	No start (FL DET. SW)
C33	30,911	20(E)	148	150(E)		NC			C015	Fuel lines pinched (Tied back)
							C		C038	Heater shut down (purged, FL DET SW, ignition control, igniter)
	30,820	24	106	118(E)			C		C062	Heater shut down (FL DET. SW, igniter, ignition control)
C34	30,830	0	0	0		NC			C011	Fuel lines pinched (tied back)
		7	70	150(E)			NC		C036	No high (purged, FL DET. SW)
	30,921	5(E)	35(E)	40(E)			NC		C074	No start (Unk)
	30,925	22	79	105(E)						
C35	30,904	0	0	0		NC			C014	Fuel leak (tightened)
		21	191	250			C		C037	Heater caught fire (purged FL DET SW, ignition control, igniter)
	30,911	5	22	108			C		C063	No start (purged, igniter, burner/wick)
Totals	16	335	1773	2735	1C	8NC	9C	1NC		
X	1.8	37	197	303	1S		2NC			
							2S			
HOURS/START			5.3							

BLACK SYSTEM (9 VEHICLES)

C = Chargeable
NC = Not chargeable

S = Secondary failure
E = Estimated
X̄ = Average per vehicle

(10 Vehicles)

Tank Bumper Number	Heater SN	Heater Starts	Heater Hours	Tank Miles	Failures (Initial Installation) Heater C/NC/S	Failures (Initial Installation) Spt Sys C/NC/S	Failures (In Service) Heater C/NC/S	Failures (In Service) Spt Sys C/NC/S	EPR #	Failure Description (Corrective Action)
C11	30,824	0	0	290			C		C019	No start (Heater lost)
	30,833	0	0	10			NC		C042	No fan/no start (purged, ADJ SW's, repaired broken wire)
	30,830	0	0	185			NC		C057	No start (ADJ FDS)
C12	30,927	22	222	245			C*		C058	No start (FL DET. SW)
C15	30,923	0	0	0	C				C002	No start (igniter)
	30,926	1	126	170(E)				C	C040	Shut down (purged, adjusted FDS, new fuel regulator & ignition control)
	30,838	30(E)	95	98(E)			C		C059	No start (IGNITER, FDS)
C22	30,827	8	166	300			C		C035	No fan (purged, FDS)
	30,829	11	120	100						
C24	30,791	32(E)	99	250					C005	No start (purged, igniter, ADJ FDS)
C25	30,928	0	0	0	NC				C001	No start (seated igniter)
	30,928	0	0	0	NC				C034	No fuel (burner, igniter)
	30,838	9	72(E)	180			C		C075	Shut down (Unk)
	30,923	8	46	78			C		C003	(Purged, ADJ FDS)
C31	30,920	0	0	0	C				C008	Heater fire (Purged, fan motor, heater fuel pump)
	30,910	1	1	0			C		C039	(Igniter)
	30,831	3	9(E)	0			C		C060	(ADJ. FDS, overheat SW, burner/wick)
		6(E)	17(E)	107			C		C068	Failed flame detecter switch caused failure (purged)
C32	30,832	12	182	200			S		C044	Failed flame detecter switch caused failure (Igniter)
		3	19	29			S		C061	No start (Igniter, FDS)
		0	2	90			C		C064	(Igniter, FDS, ignition control)
C53	30,824	21(E)	41	152			C		C043	Shut down (purged, ADJ FDS, Repl ignition control)
C66	30,822	27	27	114				C	C065	(Purged, fuel regulator, igniter)
	30,910	20(E)	78	80						
Totals	20	214	1322	2678	2C		11C	3C		
X̄	2	21	132	268	2NC		2NC			
							2S			
HOURS/START			6.2							

*Possibly related to malfunction of heater switch on DIP.

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